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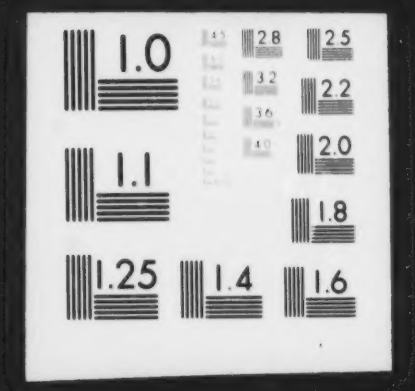

PB-238 928

GRANTS ACTIVITIES SUPPORTED BY THE ENVIRONMENTAL CONTROL ADMINISTRATION OF THE ENVIRONMENTAL HEALTH SERVICE, FISCAL YEAR 1969

Raymond T. Moore, et al

Environmental Control Administration

Prepared for:

Department of Health Education and Welfare
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A register of the grants programs of the five Bureaus which make up the Environmental Control Administration. These Bureaus are Bureau of Community Environmental Management, Bureau of Occupational Safety and Health, Bureau of Radiological Health, Bureau of Solid Waste Management and Bureau of Water Hygiene. Includes summary of objecrives and significant results of the grants research.

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GRANTS ACTIVITIES

SUPPORTED BY THE

ENVIRONMENTAL CONTROL ADMINISTRATION

OF THE

ENVIRONMENTAL HEALTH SERVICE

FY 1969

Edited by

Raymond T. Moore, M.D.
Julius J. Sabo, P.E.
Donna M. Vankirk

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE Public Health Service
Environmental Health Service • Environmental Control Administration
Rockville, Maryland, 20852

INTRODUCTION

The grants activities described in this publication were funded during Fiscal Year 1969 by the Environmental Control Administration. They were part of an accelerated national attack on high priority human hazards and health problems in the environment of the community, work, school, recreation, and the home. The aim of these grants activities was to promote the health of man by reducing the hazards occurring in occupational situations, radiation exposure, waste accumulation, deteriorating drinking water supplies, community environment, and rodent and insect vectors. Research, research training, demonstration, survey and planning, and fellowship were the kinds of grants activities supported by this program.

Universities, hospitals, research foundations and other non-profit organizations, both public and private, contribute to these efforts through the Administration's grants programs, utilizing the skill of their physicians, engineers, physicists, statisticians and other specialists. This Administration was able, by the use of the grants mechanism, to utilize the scientific expertise available throughout the nation as well as the specialized facilities that were already in existance, and achieved significant progress towards the solution of many of the environmental problems that existed. The value of this resource and the grant mechanism that makes it available, is well recognized in the Administration and by the issuance of this publication should become more apparent to all concerned.

Raymond T. Moore M.D.

Raymond T. Moore, M.D.
Acting Commissioner

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PREFACE

In this publication each of the five Bureaus which make up the Environmental Control Administration (Bureau of Community Environmental Management, Bureau of Occupational Safety and Health, Bureau of Radiological Health, Bureau of Solid Waste Management and Bureau of Water Hygiene) has a section devoted to its grants programs. This is introduced by the functional statement of that particular Bureau. The functional statement gives the overall objectives, as well as some indication of immediate priorities. Each Bureau being problem oriented has its programs subject to change, where the overall objectives are subject to change only after research effort has shown that a problem no longer exists in a specific area or there becomes an awareness of a potential for a problem in a new area; the grants supported should reflect this awareness.

In the preparation of this publication, the principal investigator or project director was requested to prepare and submit the summary statement of objectives and significant results with certain limitations as to length. The editors made corrections or changes only in the case of typographical errors or where obvious omissions had inadvertently occurred; uniformity of style was not attempted.

Grants that were active on the cutoff date of June 30, 1969, are listed and only publications that were received by the Office of Grants Administration after June 30, 1968, and before the cutoff date of June 30, 1969, are listed in this booklet. The grants program's prime objective is to make the research data that results from the funding available to the scientific community and publication in a journal with a limited distribution is not considered as being made available to the scientific community. Therefore, future booklets of this type will be more restrictive in the publications that are entered following each grant and only publications that have appeared in national scientific journals or in the proceedings of national scientific seminars and conferences will be included. This publication did not adhere to this policy and has included abstracts and theses for several but not all of the Bureaus.

Prior to 1969, each Bureau had its own system of grants data collection and to meet the publication date a uniformity in submitted data could not be accomplished.

Identification of a grant is by means of the grant number which consists of the two initials EC followed by five digits, a dash and two additional digits. The initials EC designate the

Environmental Control Administration. The five digits (including zeros) are a sequence identification number, and the two digits after the dash indicate the number of years that particular grant has received support. Grants that were transferred to the Food and Drug Administration and identified by the prefix FD are only listed and without narrative.

In the back of the booklet, there appear a numerical index of grant numbers, an alphabetical index of principal investigators or project directors and/or fellows, an index of grants by states, and an alphabetical index of grantee institutions. In this publication, grants could not be classified by program areas although this is desirable to provide an overview of the usefulness of the grants funding.

We wish to thank all of those who assisted us in the preparation of this publication especially Mrs. Evelyn Hermann, Mrs. Lorese Pinilis and Mrs. Mary Spicer of the Office of Grants Administration.

Julius J. Sabo
Deputy Director
Office of Grants Administration

Donna M. Vankirk
Grants Analyst
Office of Grants Administration

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BUREAU OF COMMUNITY ENVIRONMENTAL MANAGEMENT

Functional Statement

Formulates and establishes criteria and recommends standards for sustaining man's health and well-being in the living environment of the community. Conducts and participates in studies and demonstrations to establish data for formulating criteria and standards. Conducts or participates in research, investigations and demonstrations to control environmental hazards to health. Collects epidemiological information and maintains an information resource of statistical data on environmental hazards to health. Plans, conducts and supports a program to control injuries caused by environmental situations, human behavior and community environments. Assists in the development of manpower and training needs for community environmental management.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00140-11 (UI-00116-11)	EFFECTS OF ENVIRONMENTAL TEMPERATURE ON AGING	HAROLD D. JOHNSON UNIVERSITY OF MISSOURI COLUMBIA, MISSOURI

Objectives: An assessment of the effects that environmental temperature has upon sense of discomfort at various ages; particularly the physiological and behavioral mechanisms that are temperature related as persons increase in age.

Significant Results: This study is currently developing data which indicate that longevity and comfort are significantly impaired under conditions of cold residential stress, high food intake, and high metabolism. Significant improvements in longevity are noted when temperature thermoneutral (75-80°F) or slightly higher and food intake is restricted to less than full feeding on a balanced diet. These results seem to be correlated with the rate of growth during early age, with restricted growth rates being positively correlated with increased longevity.

Publications: No additional publications.

EC-00142-07 (UI-00128-07)	ENVIRONMENTAL ENGINEERING POLICIES AND URBAN DEVELOPMENT	F. STUART CHAPIN, JR. UNIVERSITY OF NORTH CAROLINA CHAPEL HILL, NORTH CAROLINA

Objectives: A multidisciplinary team effort at study, training, and development of the techniques and needs of urban planning.

Significant Results: This research grant, first awarded in September 1962, has made it possible for an interdisciplinary team of urban and regional

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00142-07 (Continued)

planners, economists, sociologists, political scientists, architects, engineers, and public health specialists to study in depth the complex urban land development process and to build a series of linked models based on the decision-making behavior of key agents in the growth of the urban periphery and the regrowth of the inner city. An understanding of the impact of public policies and regulations on the decisions of landowners to hold or sell and on private entrepreneurs to undertake land subdivision and residential construction has provided necessary insights for forecasting the likelihood of new housing to be made available in different locations to various income groups.

The examination of environmental amenities offered by developer-builders and local public bodies and the response of household consumers in their choice of residential location has led to a further probing of specific problems related to the land development process, such as: the housing decisions of black homeowners and renters; the patterns of residential relocation brought about by public reuse of inner city areas; public policy and the rental housing market; financial intermediaries and the effect of the tight money market on mortgage lending; and the realtor's role in raw land transactions.

In addition to providing a continuing series of published articles and monographs as a body of knowledge not heretofore available in the urban research field, the findings of the research team have been shared with local and state bodies concerned with policy decisions affecting community environmental management. Over the years a series of Development Decision Seminars has been held to consider and debate the research findings and their applicability to land use problems involving the public interest. Public service has also been performed in the training of more than twenty-five graduate research assistants in urban research techniques, the detection of urban development problems, and the formulation of alternative policies for guiding desirable growth patterns. Twelve master theses and two doctoral dissertations have been completed in the course of this research grant. It is no

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00142-07 (Continued)

exaggeration to note that the existence of this research project has made it possible to attract outstanding graduate students to the urban studies program. Former students associated with the project have since graduated to important positions in teaching and practice, in the public and private sectors. All are working, directly or indirectly, toward the solution of urban problems, in the ghetto, the inner city, the expanding suburbs, and the growing areas beyond.

Publications: Chapin, F. Stuart Jr. and Weiss, Shirley F. "A Probabilistic Model for Residential Growth," Transportation Research, Vol. 2:375-390, January 1968, University of North Carolina, Chapel Hill.

Burby, Raymond J. III. "Environmental Aspects of Municipal Policy Outputs: Planning and Growth Related Policies," A paper prepared for presentation at the Annual Meeting of the Southeastern Regional Science Association, University of North Carolina, April 18-19, 1969, 22 pp.

Weiss, S. F. (PI) "Monographs, Journal Articles, Research Papers, Research Reports, Research Memoranda, Dissertations, Theses and Major Departmental Papers," September 1962 - April 1969, A Research Compendium dated April 1969, 8 pp.

Weiss, S. F. and Kaiser, E. J. "Environmental Innovation and the Residential Development Industry," Coding Manual for N.A.H.B. Chapter President Survey. Manuscript February/ April 1969, University of North Carolina, Chapel Hill.

Weiss, Shirley F. "New Town Development in the United States: Public Policy and Private Entrepreneurship," A paper prepared for SAIPA (Journal of the South African Institute for Public Administration, Pretoria), June 1969.

Kaiser, Edward J. and Weiss, Shirley F. "A Linked Model for the Residential Development Process," A paper prepared for presentation at the 65th Annual Meeting of the Association of American Geographers, to be held at the University of Michigan, Ann Arbor, August 13, 1969.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00142-07 (Continued)

Kaiser, E. J. and Weiss, S. F. "Environmental Innovation and the Residential Development Industry." Coding Manual for Greensboro Homeowners Longitudinal Survey, 1964 & 1969, Manuscript, 82 pp. University of North Carolina.

Burby, R. J. III, Weiss, S. F., Hightower, H. C. and Kaiser, E. J. "New Towns Development Research Seminar - Series I," Spring 1968, Meetings 1 through 6 - March 13 through May 18, University of North Carolina, Chapel Hill.

Kaluzny, Richard L. "Patterns of Residential Relocation: Implications for Public Policy," A Thesis, 76 pp. University of North Carolina, Chapel Hill, 1968.

Kaiser, Edward J. "Locational Decision Factors in a Producer Model of Residential Development," Land Economics, Vol. XLIV, No. 3, pp 351-362, August 1968, University of North Carolina, Chapel Hill.

Burby, Raymond J. III. "Effective Planning for Urban Growth and Development: A Study of Environmental Influences on Municipal Policy," Manuscript, 20 pp. Prepared for Research Previews, November 1968, University of North Carolina, Chapel Hill.

Kaiser, Edward J., Massie, R. W., Weiss, S. F. and Smith, J. E. "Planners Notebook - Predicting the Behavior of Predevelopment Landowners on the Urban Fringe," AIP Journal, September 1968, pp 328-333. University of North Carolina, Chapel Hill.

Burby, Raymond J. III. "Environmental Aspects of Municipal Policy Outputs: Planning and Growth-Related Policies." A paper prepared for presentation at the 15th U.S. Annual Regional Science Association Meeting, Cambridge, Massachusetts, November 8-10, 1968 and for concurrent submission to the Journal of Regional Science. Manuscript subject to revision, 22 pp. University of North Carolina.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00142-07 (Continued)

Burby, Raymond J. III, "Politics and Planning: Toward a Model of Planning - Related Policy Outputs in American Local Government," A Thesis submitted to the faculty of University of North Carolina, Chapel Hill, 1968, 347 pp.

Kaiser, Edward J. "A Producer Model for Residential Growth," 77 pp manuscript, November 1968, Library of Congress Card # 68-66112, University of North Carolina, Chapel Hill.

EC-00164-10
(UI-00002-10)

IMPACT ATTENUATION IN PROTECTION AGAINST CONCUSSION

G. C. SNIVELY
SNELL MEMORIAL FOUNDATION
N. TARRYTOWN, NEW YORK

Objectives: Analyses of effectiveness of protective headgear and development of criteria standards for manufacture.

Significant Results: 1. A methodology was developed for the study of materials used in absorbing energy under dynamic loading.

2. Studies were made of protective headgear for road users and other people "at risk" with respect to their construction.

3. Techniques were worked out to evaluate head protective devices under dynamic loading (impact) conditions.

4. Prototype headgear coupling the results of the above were designed, resulting in very significantly increased levels of protection for the user.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00164-10 (Continued)

5. Even more importantly, the establishment of performance standards based on the above work, were set up under research in this grant. These standards were the first in this country for use by road users.

6. Grant funding enabled representation of the United States to the International Standards Organization. During the development of international standards for protective headgear and through this representation it was possible to increase very substantially the level of protection provided by these international standards.

7. Through this grant an accident analysis system was developed, paying specific and specialized attention to the aspects of head trauma and it has enabled the gathering of unique information in this area. This may be the largest such series in the world.

8. Field data have been translated into improved design of head protective devices through cooperation with many manufacturers.

9. The above accident field data have been related to laboratory duplication procedures, under controlled conditions, thus providing for an augmentation of knowledge of human tolerances to impact.

10. Development of the methodology of experimental impact studies in primate (Rhesus), has provided certain basic information in the physiologic mechanisms of concussion and brain injury.

Publications: Snively, G. G. and Snively, S. A. "Biomechanics of Head Protection," Conference on Road Safety, Brussels (1968), A3-1 to A3-15, Snell Memorial Foundation.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00165-04 (UI-00008-04)	THE EFFECTS OF HIGH VELOCITY IMPACT ON HUMAN BONES	D. F. HUELKE UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN

Objectives: To describe and evaluate the nature of human bone damage due to missile impact, including variations due to changes in projectile size, shape and velocity.

Significant Results: The study has demonstrated that little significant difference occurs in damage produced by projected impact on fresh and embalmed human bone. It has also shown that variations in structural strength of the bone significantly affects the loss of energy which the impacting projectile will experience, thus affecting the severity of damage sustained.

Publications: Heulke, D. F., Grabbe, W., Dingman, R. O. and O'Neal, R., "The New Automobile Windshield and Its Effectiveness in Reducing Facial Lacerations." Plastic and Reconstructive Surgery, Vol. 41, No. 6, June 1968, pp 554-558, Ann Arbor, Michigan.

EC-00166-04 (UI-00016-04)	VEHICLE/DRIVER STEERING DYNAMICS	E. CROSSMAN UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

Objectives: Development of a mathematical model of driver response for use in analysis and design aspects of automotive development.

Significant Results: A new methodology, with experimental equipment, has been developed to evaluate and analyze the performance of drivers and vehicles under a variety of driving conditions. These studies are expected to influence significant

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00166-04 (Continued)

improvement in automotive safety standards, highway safety design, safe auto operation and driver training, and in evaluation of safety data in auto design and product development.

Publications: No additional publications.

EC-00167-03 (UI-00020-03)

OPERANT TRAINING OF PROBLEM DRIVERS UNDER STRESS

D. H. SCHUSTER
IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
AMES, IOWA

Objectives: Evaluation of change training for problem drivers in efforts to decrease violation and/or accident rate.

Significant Results: Significant progress has been made in retraining problem drivers under stress; however, there has been no significant results. In this past year a major milestone was accomplished by moving from the hardware modification phase to the start of collecting data. Specifically, the first class for retraining problem drivers was finished on December 4, 1969. Collection of data will continue through June 1970 and the results from these research data should be available in the second half of 1970.

Publications: Schuster, D. H. "Evaluation of a New Hybrid in Programmed Instruction." Journal of Applied Psychology. 52(4):309-312, 1968, Iowa State University.

Schuster, D. H. "Attitudes Toward Driving Safety and Their Modifications," Paper given at the Human Factors Society Meeting, October 1968, 8 pp. Iowa State University.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00168-03 (UI-00031-03)	DRIVER-VEHICLE STABILITY AND CONTROL STUDIES	I. R. EHRLICH STEVENS INSTITUTE OF TECHNOLOGY HOBOKEN, NEW JERSEY

Objectives: Definition of physiological and psychological factors in automobile driver behavior in relation to the physical environment of the vehicle and the highway.

Significant Results: The investigation demonstrated that driver response is highly influenced by the characteristics of the vehicle; and that psychological traits, identifiable on standard tests, have distinct relationships to driver accident behavior on violation experience.

Publications: No additional publications.

EC-00169-03 (UI-00033-03)	AUTOMOBILE COLLISION RESEARCH FOR INJURY REDUCTION	HARRY W. CASE UNIVERSITY OF CALIFORNIA LOS ANGELES, CALIFORNIA

Objectives: Evaluation of automobile safety devices in reduction of motorist injuries.

Significant Results: The numerous full-scale collision experiments that were conducted provided the data that substantiated the value of seat belts, shoulder harnesses, head restraints, collapsible steering columns, and improved windshield glazing techniques. Since this program started, all of these items have been incorporated in the Federal Motor Vehicle Safety Standards.

Specific research and its application to current safety standards are as follows:

1. Two related series of side impact collisions established the need and requirements for door latch strength, hinge retention, side window glass and seat structures.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00169-03
(Continued)

2. A series of 12 controlled collisions involving simulated pedestrians provided data relating to vehicle exterior design for minimization of pedestrian injury.

3. Two series of rear-end collision experiments (a total of 16 full-scale collisions at speeds from 10 mph to 55 mph, including the first controlled experiment involving postcrash fire). These experiments provided the necessary engineering data for the head-restraint safety standard No. 202.

4. School bus collision experiments have delineated the requirements for safer bus seats and passive restraint systems. Additionally, the problem of large-small vehicle underride was evaluated and recommendations for solution of the problem were made.

Publications: No additional publications.

EC-00170-03
(UI-00039-03)

THE PREVENTION OF SKI ACCIDENTS

J. O. OUTWATER
UNIVERSITY OF VERMONT
BURLINGTON, VERMONT

Objectives: Design and development of improved safety measures and educational materials for ski bindings and ski lifts, including testing devices, design criteria and training programs.

Significant Results: A complete study has been made of the source, nature and causes of ski injuries. This has led to recommendations in regard to the details of prevention that can be used by equipment manufacturers and by the general public.

Over 32,000 individual ski accident reports were examined statistically to determine the most important type of injury as well as the causes of accidents. The torsional fracture of the lower leg was the most important accident, therefore efforts were directed to its prevention.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00170-03 (Continued)

It was just this type of accident that release bindings were designed to prevent, but the actual understanding of the causes of this form of accident as well as the loads that the leg could stand were not known. A twist measuring device was designed and built to determine exactly what forces were needed for proper maneuvering on skis. It was shown that these forces were far below those that would break a leg so it was definitely possible to ensure adequate attachment between the boot and the ski for satisfactory skiing and yet enable the binding to release on an overload. The strength of the leg bone itself was determined indirectly from earlier data as well as from x-ray measurements of actual leg fractures. These strengths were related to body sizes for skiers by computer analyses so the skiing public would be able to calibrate its bindings to release before the leg broke.

A binding tester was designed and built so that the actual performance of boot-ski attachment devices could be tested under conditions simulating actual skiing. By this means evaluation can be made of devices presently on the market and constructive criticism can be given in regard to their shortcomings or advantages. It was found that no bindings presently available were satisfactory and some of the most popular were the most unsatisfactory from the safety viewpoint.

A hydraulically-operated binding tester was also designed and built so that the habits of the public could be studied. The actual binding tension used by the public was determined on a large number of persons and recommendations were tried and the public reaction noted.

Through this project real and practical results are beginning to be seen in the present modification of attitude and technique towards accident prevention in this hitherto hazardous sport.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00171-03 (UI-00040-03)	PREVENTION OF ACCIDENTAL HEAD INJURY	A. M. NAHUM UNIVERSITY OF CALIFORNIA LOS ANGELES, CALIFORNIA

Objectives: Determination of concussion forces and resulting clinical and pathophysiological changes in the central nervous system in simulated accidental head injuries. Development of effective countermeasures to reduce or prevent accidental head injuries.

Significant Results: To date, using subhuman primates, the project has successfully introduced and tested new techniques of assessive neurophysiologic function using technology utilized for the biosatellite program at UCLA. This instrumentation consists of implanted intracerebral electrodes which continuously measure EEG, impedance, intracranial pressure, and discharges from multiple neuron units (unit recordings). Following this, varying degrees of clinical concussion were produced by applying carefully measured blows to the head, simulating the circumstances of human head injury. The data produced have been analyzed by computer spectral analysis. Early analyses have shown that, indeed, cerebral concussion can be correlated by discrete changes in deep EEG recordings from the reticular activating system in the brain and with impedance changes as well.

Work is now underway to assess the preventive benefits of such protective devices as head restraints and energy absorbing materials.

Publications: No additional publications.

EC-00172-05 (UI-00057-05)	EFFECTS OF SELF-PERCEPTION ON DRIVING BEHAVIOR	DOROTHY S. EDWARDS AMERICAN INSTITUTE FOR RESEARCH SILVER SPRING, MARYLAND

Objectives: Assessment of effects of driver performance feedback in altering accident prone behavior.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00172-05 (Continued)

Significant Results: The program has developed a design by which drivers are exposed to filmed records of their own driving behavior, tested for motor skills, and participate in group training programs which attempt to alter driving patterns through increased awareness of self-performance feedback. Results indicate that non-specific behavior and attitude change approaches to driver re-education are less effective in reducing traffic accidents than is the self feedback approach. A documentary film has been produced for driver training groups and for television presentation.

Publications: No additional publications.

EC-00173-03 (UI-00064-03)

ACCIDENT PREVENTION BY CONTROL OF TRACTOR TIPPING

J. B. LILJEDAHL
PURDUE RESEARCH FOUNDATION
LAFAYETTE, INDIANA

Objectives: To classify various conditions and behavior patterns which lead to and occur during tractor overturns.

Significant Results: A ride simulator has been completed to study the reaction time of operators as they use several types of manual controls. The actual study on drivers will begin February 1970. The objective of this phase of the study is to search for manual controls which would reduce the time required to cause a tractor control to move, especially during emergency conditions such as when it is approaching an overturn condition.

The major conclusions from a study of 145 non-fatal tractor overturning accidents in Indiana are as follows: Twenty-one percent of the drivers recalled trying to make some last moment effort to prevent the tractor from overturning, but were unable to do so. About 50 percent of the upsets occurred on level land. None of the accidents could be attributed to weather or to a mechanical failure, and only one indicated that a physical handicap might have helped cause the accident. Side upsets accounted for 83 percent of all overturns. Drivers under 20 years of age accounted for 86 percent of the

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00173-03 (Continued)

accidents at speeds of 5 mph or greater, but only 43 percent of the total sample. Front mounted manure loaders were associated with more tractor overturning accidents (25 percent) than any other implement or attachment. Of the tractors which were equipped with manure loaders and overturned, only one was being used for its primary function of loading manure.

It appears that poor judgment was a major cause of most of the accidents. Suitable warning devices and/or improved manual controls might have reduced the number of overturn accidents. Similarly, more and better operator education would reduce the number of accidents.

Good progress has been made in developing mathematical models to predict the overturning of tractors. Models have been developed for both rear and side tipping. The rearward tipping mathematical model has been confirmed by actually overturning an instrumented tractor.

The rearward tipping mathematical model was the basis for the development of an experimental device to measure the stability of the tractor and by using a logic circuit the tractor clutch was automatically disengaged before the tractor became unstable. The device, as designed, was not as reliable nor as simple in design as hoped for.

A major problem in developing mathematical models of tipping tractors was how to include the effect of odd shaped obstacles and holes on the stability of a moving tractor. This problem was successfully solved by converting odd shapes into equivalent profiles and also by determining the dynamic spring and damping rates of pneumatic tires on soil.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00174-03 (UI-00066-03)	AUTOMOBILE DRIVER CONTROL: ACCIDENT CAUSATION FACTORS	G. H. ROBINSON UNIVERSITY OF WISCONSIN MADISON, WISCONSIN

Objectives: Development of a more national design for driver control to reduce accidents associated with driver-automobile linkage systems.

Significant Results: The research program has continued under the concept that a coordinated laboratory and field study of basic human performance restrictions will lead to accident prediction abilities in complex man-machine systems. The performance areas selected as being applicable to the problem and understood sufficiently to permit quantitative investigation are: (1) visual search, (2) control of attention, and (3) perceptual-motor control.

Visual search data have been gathered in the laboratory and in automobile driving (the "field" area selected to parallel the laboratory). A study has been completed in the laboratory on eye-head coordination and the interaction of performance times with task difficulty. A second laboratory study is investigating the process of learning the skill of visual search. Two "field" investigations include a completed study of automobile drivers search patterns at an intersection, and a currently ongoing study of search problems during freeway merging and lane changing.

Attention control was investigated in a dual control task using a hybrid computer for experimental control. A second experiment evolving from this has just been completed and yields data on the human abilities to trade off attention as task demands change and to respond to changes in the costs of inattention. This study also includes a discussion of the correlation between the laboratory measurements and a risk propensity assessment by questionnaire.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00174-03 (Continued)

Perceptual-motor control studies have been extended to include realistic variables found in man-machine systems. Positioning control was investigated using variable control force, control of dynamic systems, and alcohol stress. Experiments are now underway looking at visual search during motor control and the effects of unpredicted forces on controls.

Publications: No additional publications.

EC-00175-02 (UI-00067-02)

SELECTIVE ATTENTION IN ACCIDENT PREVENTION

A. BINDER
SYSTEMS DEVELOPMENT CORPORATION
SANTA MONICA, CALIFORNIA

Objectives: Determination of cues, distractions and driver characteristics which reduce or enhance the probability of driver-associated accidents.

Significant Results: The research is run in a computer-based laboratory in which subjects respond to various changes in visual stimulation. These responses are evaluated in terms of speed and accuracy. It is assumed that a deterioration of performance (speed or accuracy) is associated with increasing probability of an accident in corresponding real-life contexts.

In an experiment recently completed, subjects had to process visual information from two sources while giving two independent sets of responses. One of these sets, movements of a light source, was repetitious in the sense of being required on each trial (defined by movement of a computer-controlled light source). The second set, pedal pushes, was necessary on some trials, but not others as a function of the particular type of information displayed. The computer-controlled light source changed in a regular or random manner from trial to trial, and the subject tracked accordingly.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00175-02
(Continued)

Subjects were required to perform mental tasks during the experiment to determine the potential effects of preoccupation upon the likelihood of an accident. Three levels of preoccupation and a control condition were used.

To approximate situations involving a routine (well-practiced) perceptual-motor task, subjects were run over a three-day period, two hours per day. Each subject was run under all experimental conditions so that individual differences were eliminated from experimental comparisons. There were 1,000 trials each day.

Differences in the effects of preoccupation upon performance showed up most clearly in the third day. But the deleterious effects were restricted to speed of reaction; no effects upon accuracy were noted. The patterns of slower reactions were similar in both repeated and discriminative responding. But random tracking was interfered with to a greater extent than systematic tracking.

The results of the experiment would seem generalizable to situations that involve both a central routine task dependent upon regular sequential information and subsidiary response adjustments dependent upon sporadic visual cues. Many industrial jobs, routine household tasks, driving, piloting an airplane or a boat, and many classroom activities seem to fall in the appropriate category.

Mental preoccupations, incidental to but not necessary for such tasks, seem to interfere more immediately with the rate rather than the accuracy of performance of the tasks. And the degree of interference is directly related to intensity of preoccupation and to the amount of information being processed from external sources. Obviously, the channel capacity of humans is limited and where these preoccupations are placed in a position of required attention, other information processing suffers.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00176-01 (UI-00069-01)	SWIMMING PROFICIENCY AND DROWNING	FRANK WESLEY PORTLAND STREET COLLEGE PORTLAND, OREGON

Objectives: To determine those factors, including swimmer skill, which lead to high risk of drowning.

Significant Results: The study indicates that increased swimmer proficiency does not, as previously held, diminish the risk of drowning. It does indicate that instruction methodology should include consideration of water and physical dynamics which tend to increase swimmer risk. Results have been widely distributed through public media. Study completed.

Publications: None

EC-00177-02 (UI-00082-02)	FATAL TRAFFIC ACCIDENTS IN A NON-DRINKING POPULATION	W. P. DYSINGER LOMA LINDA UNIVERSITY LOMA LINDA, CALIFORNIA

Objectives: Comparative evaluation of motor vehicle mortality among non-drinking drivers and that among the general population of California to determine the associated causes of motor vehicle accidents exclusive of intoxication.

Significant Results: The purpose of this study is to help clarify the significance of alcohol association with auto accident fatalities and to pinpoint auto accident problem ages or groups to which education, legislation, or other remedial measures might be directed. To do this, auto accident fatality statistics for a seven-year period - 1960 to 1966 - have been analyzed for a population of some 80,000 Seventh-day

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00177-02 (Continued)

Adventists (S.D.A.'s) in California and compared with the general California population. S.D.A.'s are non-drinkers by religious proscription and all evidence points to this religious tenet being rather strictly followed. Their religion, however, does not improve their general driving habits as shown by the evidence that they accumulate a significantly greater number of driving violations per person than does the average Californian. In fact, there is evidence that they have even more non-fatal accidents than would be expected for the average Californian, but fewer accident violations. In per miles driven, there is evidence the S.D.A.'s do as much driving as the general California population with additional evidence that they do less long-distance driving but more night driving than the California group.

The greatest difference between the groups under study occur amongst the males and especially in the age group 25-44. In this age group, the S.D.A. study population has only some 67% its expected number of fatalities. The type of accident showing the greatest difference is the pedestrian accident, with the male pedestrian deaths being only 56% the expected figure for the California population and in the age below 65, only 12% the expected rate. Single car accident fatalities among S.D.A. males are only 80% the expected rate and in the age group 25-44, it is only 50% the expected rate. Additional analysis of the auto accident mortality in a prospective study of some 48,000 S.D.A.'s enrolled in 1958 shows even greater differences from the expected rates for general Californians of the same age and sex -- and all differences are in the same direction as those quoted for the total S.D.A. population.

It is believed that this study substantiates that the major differences in this study are due primarily to differences between the amount of alcoholic consumption. Drinking while driving is a recognized problem in the U.S.A. and this study suggests that programs and education directed against this problem can be pinpointed to males aged 25-44. The types of fatalities which show promise of greatest improvement are the pedestrian and single car accident fatalities. Recognizing that many die from other types of accidents, this study suggests that factors other than alcohol need to be studied and clarified for these other types of accident fatalities.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00177-02 (Continued)	Publications: None	
EC-00179-04 (UI-00160-04)	COMPREHENSIVE PROGRAMMING OF PUBLIC FACILITIES	BENJAMIN STEVENS REGIONAL SCIENCE RESEARCH INSTITUTE PHILADELPHIA, PENNSYLVANIA

Objectives: An assessment of the importance of public facilities as they affect the comprehensive planning for urban development.

Significant Results: The study has developed a mathematical model for goal achievement in program planning which has been derived from data collected from 101 metropolitan communities regarding physical, mental, and social health. These data have been further analyzed relative to the location of mental health and hospital services and highway distribution. An attempt is now being made to optimize urban form with regard to minimizing air pollution and maintaining the existing natural facilities and aesthetic goals of the community. Recommendations for goal achievement programming have been accepted by various public and civic planning groups in the city of Philadelphia.

Publications: No additional publications.

EC-00184-03 (UI-00195-03)	HOUSING AS INVESTMENT IN ENVIRONMENTAL HEALTH	LELAND S. BURNS UNIVERSITY OF CALIFORNIA LOS ANGELES, CALIFORNIA

Objectives: Evaluation of the impact of improved housing quality upon health, school attendance and performance, and crime rates in a variety of local test sites.

Significant Results: Preliminary results suggest that a sharp improvement in housing quality will under certain conditions induce better physical and mental health and be reflected positively in a variety of ways which contribute to the quality of life. However, the types and size of effects vary among case studies. Investment in other

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00184-03 (Continued)

facilities, including free public health clinics and services, partly alleviate the deleterious effects of poor quality shelter and utilization of these services but does not always change with improved housing. However, the utilization of health facilities and services with rehousing tends to be accompanied by a change in the need for care. Housing related illnesses, such as infectious and parasitic disease decline and increases occur in other categories.

The system of delivering better housing to families plays a role in determining the impact on health and welfare. A change from low density slum housing to high density "safe and sanitary" housing may aggravate problems of social deviance in the short-run. The general expectation that improved housing will produce massive change in attitudes, health, and performance at jobs and in schools will not be realized unless care is exercised in relating the new housing to the special needs of the population concerned.

Publications: Wambem, Dennis. "A Case for Housing Subsidy," Preliminary Report, 8 pp, April 22, 1969, International Housing Productivity Study, University of California, Los Angeles.

EC-00191-05 (UI-00287-05)

RESIDENTIAL PHYSICAL ENVIRONMENT AND HEALTH OF THE AGED

KERMIT K. SCHOOLER
BRANDEIS UNIVERSITY
WALTHAM, MASSACHUSETTS

Objectives: Effects of residential environment, social interactions, and adjustments in increasing or reducing the actual and perceived physical and mental health of the elderly.

Significant Results: The primary focus of our research has been on the study of the relationships between characteristics of the residential environment and the health and emotional well-being of the elderly. To date, the principal findings of a substantive nature have been to confirm the association between various characteristics of the residential environment and measures of morale of the elderly. Through the procedures of factor analysis, 6 classes of residential environmental characteristics were defined. Through these same procedures, 6 factors of morale were defined. Considering each

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EC-00191-05 (Continued)

morale factor as a dependent variable, it was found that modest but statistically significant correlations could be obtained with combinations of environmental factors. Several factors pertaining to the maintenance of social relationships were also derived. It appears now that while the maintenance of social relationships is also important to sustaining a level of morale, these factors in themselves are relatively less important than the environmental characteristics.

Findings of value from the methodological, as opposed to the substantive, standpoint have also been obtained. The usefulness of multiple factor analysis for classifying characteristics of the environment has been demonstrated. The measures of morale obtained through factor analysis will also represent a contribution to the field. Other statistical procedures have been and will be tried, the most promising among them being path analysis and canonical correlation.

Over and above the value of specific substantive and methodological findings will be the value of present data themselves for the establishment of baselines against which the results of subsequent research will be compared. The body of data represents one of the largest, if not the single largest, rigorously drawn sample of elderly persons in the U.S., outside of the federal government, and ought to have utility beyond the period currently funded.

Publications: Schooler, Kermit K. "The Relationship Between Social Interaction and Morale of the Elderly as a Function of Environmental Characteristics." The Gerontologist, 9(1):26-29, Spring 1969, Brandeis University, Waltham, Massachusetts.

GRANT NO.	TITLE OF PROJECT, OBJECTIVE, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00247-03 (UI-00025-03)	HUMAN BODY UNDER TIME-DEPENDENT BOUNDARY CONDITIONS	Y. K. LIU UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN

Objectives: Determination of site, mechanism and time of occurrence of injuries to the human body during accident impact.

Significant Results: Two principal areas of research were mapped out: (a) Spinal injuries due to vertical and/or horizontal impact and (b) closed head injuries due to a blow. These two areas were chosen because they represent the most critical ones from the standpoint of current injury prevention and control.

Approximately 75% of the fatalities resulting from all accidents involve injury to the head, emphasizing the special vulnerability to this part of the human body. The important contribution made to this problem was an assessment of the effect of the elasticity of the skull on the intracranial pressure distribution. Previous studies assumed a rigid fluid-filled shell as a model of the head during impact. This assumption was the source of considerable misunderstanding of the head injury phenomena. This fundamental delineation of the injury mechanism has major implications in helmet design, treatment and care of patients with closed head injuries.

Injuries to the spine under dynamic conditions occur in a wide variety of circumstances. A model for the spine has been developed which accounts for the initial curvature, variations in material properties and area cross sections and the inertial properties of the upper torso. Fundamental information is sought on how the spine articulates during impact. This information is already of practical significance in the design of pilot ejection seats for high performance aircraft, the whiplash (rear-end collision) and seat-belt syndromes (front-end collision) in automobile accidents.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00282-02 (UI-00619-02)	MODIFICATION OF HIGH RISK BEHAVIOR IN CHILDREN	N. W. HEIMSTRA UNIVERSITY OF SOUTH DAKOTA VERMILLION, SOUTH DAKOTA

Objectives: To define processes which underlie behavior in children which pose high accident risk.

Significant Results: A test was developed which effectively measures children's perception of hazard. Essentially, it involves a forced choice rating system where children rate various scenes (photographs) in terms of the amount of hazard depicted. Test-retest reliability of this system is high. Approximately 1500 first, third, and fifth grade children have now been tested. Preliminary data analysis suggests that differences in perception of hazardous situations may be expected as a function of the age of the children, sex, socioeconomic background, and rural or urban backgrounds. For example, the preliminary analysis indicates that children from lower socioeconomic background tend to not rate scenes depicting children ingesting aspirin as particularly hazardous while children from higher socioeconomic backgrounds view this as quite hazardous.

The development and utilization of the "perception of hazard" test is important from several points of view. For the first time information is being obtained concerning basic perceptual characteristics of children which may be critical in terms of whether or not they engage in behavior resulting in injury or death. Understanding of these processes will permit us to develop more effective countermeasures. It appears that this test may have some predictive value. That is, certain scores may be associated with children who tend to have accidents while other scores may be indicative of low accident rates. The preliminary work shows that this test may be useful in determining whether various types of countermeasures--movies, posters, lectures by teachers or law officers--are effective. It will be possible to utilize the test to systematically evaluate countermeasures. Each of the above represent critical areas of interest in injury control.

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EC-00282-02 (Continued)	Publications: None	
EC-00285-02 (UI-00642-02)	A PHYSICAL, CHEMICAL AND PHARMACOLOGICAL STUDY OF THE NEMATOCYST FLUID OF CHRYSAORA QUINQUECIRRHA	JOSEPH W. BURNETT UNIVERSITY OF MARYLAND BALTIMORE, MARYLAND

Objectives: To develop a method by which the toxic fluid in the jellyfish sting may be refined and stored for experimental use to determine the toxicological mechanisms involved in the stings which swimmers experience.

Significant Results: A series of investigations have revealed that 10 different types of nematocytes are present on the fishing tentacle of the sea nettle. It is not certain of their relationship with one another or which types produce the sting in humans. Previously only 3 or 4 types of these structures had been reported in this organism.

The ultrastructural anatomy of the fishing tentacle has been fully delineated.

The nematocyst toxin has been found to be capable of producing transient vasopressor responses and ischemia and conduction abnormalities on the electrocardiogram of the mammalian heart. Complete heart block appeared prior to death. Some of these changes were transiently corrected by atropine. This toxin also blocks the action potential of skeletal muscle and peripheral nerve. The conduction velocity of skeletal muscle and peripheral nerve were unaffected. Both the tonic and peristaltic contractions of the rat ileum were also obliterated after exposure to the toxin.

The chemical composition of sea nettle nematocysts was further studied. An unusually high concentration of cholesterol was found in these structures--a finding which might

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EC-00285-02 (Continued)

indicate the content of lipid in organelle membranes. A collagenase extractable material having an amino acid content similar to that of invertebrate collagen was found in the nematocysts. These data indicate that these structures do indeed contain collagen.

Immunological studies now in progress establish the fact that the lethal toxin is weakly antigenic at best. This would support the fact that the clinical sting is due to a poisonous rather than an antigenic substance. Multiple attempts to propagate tentacular tissues in vitro did not achieve significant results.

Publications: None

EC-00286-03 (UI-00023-03)

THE EPIDEMIOLOGY OF SKI INJURIES

MARK B. COVENTRY
MAYO FOUNDATION
ROCHESTER, MINNESOTA

Objectives: The primary objective of the proposed study is to define the differences existing between injured and non-injured skiers, and to prove or disprove the numerous unsupported theories in existence regarding ski injuries. The project will study factors within the direct control of the individual skier as well as the ski area and its ancillary facilities. Information gained from the study offers potential utilization by the skiing public, ski schools, ski patrols, equipment manufacturers, as well as medical personnel dealing with ski injuries.

Significant Results: Analysis of the information gathered from 3000 uninjured and 2124 injured skiers, revealed the following:

1. Between the ages of 10 and 45 years, injury rates decrease with increasing age. After age 45 injury rates tend to increase with age. This latter increase is more marked for females and lower ability classes.

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EC-00286-03 (Continued)

2. The passage of the skier from the novice to the intermediate ability class results in a decreased injury rate.

3. Almost without exception, females, regardless of their age and/or ability, demonstrate a higher injury rate than do males of comparable ages and abilities.

4. The proportion of skiers injured at any particular time of day is related to the population at risk and does not appear to be related to personal factors, weather or snow conditions, etc.

5. The likelihood of an injured skier reporting his injury to the ski patrol is related to the severity of his injury as well as age, sex and skiing ability. At least fifty percent of all injured skiers who ultimately require a physician's care do not report their injuries to the ski patrol.

6. The overall rate of incidence of ski injuries (injury rate) appears to have decreased over the past ten years. This decrease does not appear to be the result of any single variable (e.g., items of equipment), but rather a reflection of a number of changes in skiing and the ski population (e.g., a rising proportion of more expert skiers, improved slope grooming methods, etc.).

7. The type and severity of the ski injury is independent of skiing expertise.

8. Skiers are generally injured while skiing on terrain judged consistent with their abilities.

9. Cable type heel bindings are generally associated with a higher incidence of injury by the user than are "latch-in" or "step-in" type heel bindings.

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EC-00286-03 (Continued)

10. During the first few years of skiing experience, skiers who have taken formal ski lessons progress more rapidly to more advanced levels of ability than do untutored skiers.

Further analysis of the above material, as well as analysis of other variables, is currently in progress.

Publications: No additional publications.

EC-00287-02 (UI-00669-02)

DYNAMIC RESPONSE OF AIRCRAFT SEAT AND RESTRAINT SYSTEMS

NELSON M. ISADA
THE RESEARCH FOUNDATION OF THE STATE UNIVERSITY OF NEW YORK
ALBANY, NEW YORK

Objectives: This study was made to determine the factors that affect the crashworthiness of aircraft seat and passenger-restraint systems. It is hoped that through this study the effect of the high deceleration inputs to the seat and passenger-restraint system can be reduced so that the chances of survival during a crash landing and rapid egress afterwards can be increased. It is also hoped that the probability of detachment of passenger seats and their backs from their mounts during crash landings together with the temporary loss of the passenger's senses will be minimized through energy dissipation and pulse reshaping of the shock input from the airframe.

Significant Results: 1. It has been found feasible to develop computerized mathematical models which simulate the dynamics of aircraft seat and passenger-restraint systems. The practical significance of this knowledge is: (1) the development of a simplified operational computerized mathematical model used in the development of tentative isodamage crash curves to be described below and for use by aircraft seat designers, and (2) the

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00287-02 (Continued)	possible development of experimentally validated computerized mathematical model to supplement expensive and time-consuming crash tests.	

2. From the simplified computerized mathematical model it has been found that the responses of aircraft seat and passenger-restraint system depend upon several major factors, namely, (1) the yield strength of the seat, (2) the ultimate strength of the seat, (3) the natural frequency of the seat-passenger-restraint system, (4) the duration of the aircraft deceleration and (5) the magnitude of the peak aircraft deceleration. A major significance of the isolation of the foregoing factors is to show the way on how to construct critical isodamage crash curves.

3. From the computerized mathematical model and the knowledge of the major variables involved, it was found feasible and possible to construct tentative critical isodamage crash curves which can be used as: (1) a guide in the modification of existing seats, (2) a guide in the design of new seats, (3) an important measure of the crashworthiness of existing, modified or proposed new seats and (4) a guide in the design and instrumentation of crash simulators.

4. The study revealed that it is feasible to install shock absorbers with the seat and that these absorbers significantly increase the seat's crashworthiness. The significance of this finding is to back up a recommendation that shock absorbers be included in future seats.

5. It was found that the inclusion of an air bag between the passenger and the back of the seat increased the seat's crashworthiness in addition to protecting the passenger from pitching and impacting of the seat.

6. It was found feasible and possible to design and build a simple, rugged and effective variable slope crash simulator for use to test models of aircraft seats and prototypes of aircraft seat and restraint systems for their crashworthiness.

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EC-00287-02 (Continued)

7. It was found feasible and possible to use commercially available transducers, instrumentation, recording devices and photographic equipment in crash simulation tests. This knowledge saved development costs.

8. Although considerable knowledge has been gained in this study, it was found that further research is needed to provide highly crashworthy aircraft seat and passenger-restraint systems. Some of the research needs are: (1) development of computer programs for the complex mathematical models developed in the study, (2) crash simulation testing of prototype aircraft seats, (3) development of quick release valves and anti-cluttering devices for air bags, (4) development of supplemental criteria for crash-worthiness, and (5) design and development of new seats.

Publications: None

EC-00301-01 (UI-00744-01)

OUTDOOR RECREATION OPPORTUNITY: NEEDS AND DESIRES

GEORGE L. PETERSON
NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS

Objectives: This newly awarded grant proposes to develop a more adequate understanding of the needs and desires of urban people for open recreational space, and to use such information to develop more effective foundations for urban planning and development.

Significant Results: A pilot study of urban beaches has been completed. In this study it was learned that "two groups having distinctly different preferences are identifiable. The larger group prefers scenic natural beaches, is attracted by trees and natural growth, and finds crowding distasteful; the smaller prefers city swimming beaches, is sensitive to sand quality and attractiveness of surrounding buildings but insensitive to crowding or greenery."

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EC-00301-01
(Continued)

Investigations of a wider range of activities are currently being designed. A method for codifying the characteristics of activities and environments has been developed and a set of photographs has been collected for use in psychological tests. Environmental perception and preference tests, environmental disposition tests, and social disposition tests are being developed. These will be implemented in the near future.

Publications: None

EC-00303-02
(UI-00752-02)

SAFEST LOCATION IN HOUSES IN SEVERE WEATHER

J. R. EAGLEMAN
UNIVERSITY OF KANSAS
LAWRENCE, KANSAS

Objectives: To evaluate actual and simulated destruction of buildings by tornadoes, and to define safest locations and new design approaches which will serve to reduce injury.

Significant Results: Damage surveys to date indicate that for houses without basements, the section of the house on the opposite side from the approaching tornado is the safest. This is generally the northeast part of the house since over two-thirds of the storms approach from the southwest. For most of the storms, the southwest part of the houses were unsafe about twice as often as in the northeast section. If this remains true for all storms, the potential for reduction of numbers of injuries is quite large. Data obtained on houses with basements also indicate that the northeast part of the house is safest for a tornado approaching from the southwest.

Wind tunnel experiments are currently in progress. Initial results indicate the pitch of the roof of houses is quite important in influencing the pressure distribution and ability of the structure to withstand high winds. Upon completion of these tests it will be possible to recommend improved design criteria which will enable houses to withstand greater stresses.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVE, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00305-02 (UI-00760-02)	ULTRASTRUCTURE OF NEMATOCYSTS AND PRIMITIVE TISSUES	JANE A. WESTFALL KANSAS STATE UNIVERSITY MANHATTAN, KANSAS

Objectives: A study of the characteristics of jellyfish stinging cells which enhance or diminish the severity and incidence of stings encountered by swimmers.

Significant Results: In FY 1969, ultrastructural evidence was produced for the first time of neuronematocyte and neuromuscular synapses in the Cnidaria. These synapses, moreover, resemble those of higher animals in that they possess an aggregation of vesicles on the neural side of two parallel thickened membranes which have a short filamentous fuzzy coat on the cytoplasmic surface. The synaptic vesicles (1200-1400Å diameter) contain dense cores which suggest that the neurotransmitter is a catecholamine as has been shown for dense core synaptic vesicles in higher animals. The ultrastructure demonstration of morphologically polarized neuronematocyte and neuromuscular synapses in the Cnidaria, a phylum possessing the lowest level of tissue organization, provides a basis for functional and evolutionary correlations previously postulated only on the basis of physiology and specialized light microscopy.

Electron microscopic studies in the laboratory further revealed two sequentially located synaptic junctions associated with a nematocyst. The first synapse is an interneural synapse and the second is a neuronematocyte synapse. Together these provide ultrastructural evidence for a neural-neural-nematocyte sequence of transmission of chemical excitation that may possibly influence the control of nematocyst discharge.

The above findings were made in the primitive hydromedusan Gonionemus (Hydrozoa), Even more recent electron microscopical observations in the laboratory have revealed,

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EC-00305-02 (Continued)

again for the first time, synapses in a sea anemone, Metridium (Anthozoa); and, in addition, have shown true neuromuscular synaptic junctions in these animals. Current efforts are directed toward tracing the neural pathways in these evolutionarily primitive species. Ultimately, these observations will contribute to an understanding of the function of the brain of the most highly evolved species, namely, man.

Publications: None

EC-00308-01 (UI-00800-01)

NEW TOWN DEVELOPMENT--CONVERGENCE OF CONCEPT AND REALITY

SHIRLEY F. WEISS
UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, NORTH CAROLINA

Objectives: Reduction of environmental and psychological health hazards in the planning of new towns.

Significant Results: Significant results have not yet materialized as this project is in its first year of support.

Publications: None

EC-00311-01 (UI-00846-01)

THIRD INTERNATIONAL CONGRESS ON TRAFFIC MEDICINE

MILTON HELPERN
NEW YORK UNIVERSITY MEDICAL CENTER
NEW YORK, NEW YORK

Objectives: Partial support of Third International Congress.

Significant Results: Congress completed with grant providing one-third of total cost. Proceedings not released as yet.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVE, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00312-01 (UI-00847-01)	INJURY PREVENTION: THE DANGEROUS DRIVER	F. R. ERVIN MASSACHUSETTS GENERAL HOSPITAL BOSTON, MASSACHUSETTS

Objectives: This new grant will investigate the relationship between the dangerous driver and brain disfunction.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

EC-00320-01 (UI-00877-01)	DECISION PROCESS GAMES FOR ENVIRONMENTAL HEALTH PLANNING	JOHN M. ALLDERIGE CORNELL UNIVERSITY ITHACA, NEW YORK

Objectives: Design, testing and product development of three operational games in elementary environmental health planning. The games are planned for use as aids in training environmental health professionals, for research tools in decision making, and as a basis for more complex games in urban health studies.

Significant Results: The project is charged with producing a series of three decision process games. One of these has been completed, the other two are in progress. The completed game, VIRON, is an independent exercise while the other two are really add-ons to existing operational games METROPOLIS and APEX, both developed by the Environmental Simulation Laboratory at the University of Michigan.

These gaming exercises are distinctive in that they permit the participant to have "hands on" use of a computer to work with simulators thus assisting in the decision-making processes of the game itself. They are aimed at teaching the more effective use of personalized computing, public system simulators, and basic system control techniques.

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EC-00320-01
(Continued)

There has been insufficient exposure of these exercises to comment on their effectiveness as training aids. An accelerated pace of sessions is now underway with both professionals and students.

Publications: None

EC-00322-01
(UI-00899-01)

PERCEPTUAL ACCURACY AND INTEREST IN URBAN SPACES

LEO JAKOBSON
UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN

Objectives: Construction of simulated environmental models which will facilitate the testing of hypotheses relating to various aspects of urban spacing.

Significant Results: The initial effort during the spring of 1969 focused on a refinement of the original analysis matrix of environmental form variables. Specifically, an attempt was made to correlate project designs with actual building and development practices. The principal investigators felt that approximation to real situations would help subjects orientation in the simulated environments, and that the by-necessity abstract projected images in the simulated environments would become more easily recognizable if the subject would be able to correlate the abstractions with familiar, real environments.

Another area to which attention was given was the ordering of the environmental variables in a manner in which each successive step in the matrix would result in an environment with a clearly measurable degree of added complexity. In these analyses it was observed that the bits of information required for added complexity at each step operated at various scale levels which were not additive as such. For example, the grouping and building form variables operate at different levels of scale, therefore requiring different distances in observation position in order to be recognizable.

A third attempt was made to eliminate "intuitive" interpretations of the environmental variables by the designer in the lay-out of the various test environments. A simple

GRANT NO.	TITLE OF PROJECT, OBJECTIVE, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00322-01 (Continued)

coordinate grid was developed on which the grouping and clustering of buildings was done by the use of a random numbers table.

The analyses during the spring semester led to a redesign of the matrix to a format that conceptually is clearer and in practice is easier to use.

During the summer and fall emphasis has been on the development of simple model making techniques which would allow for flexibility in use of the models, and which would reproduce projected images that can be easily read and understood. A modular system was developed and all required modular units have been cast by now. However, due to long manufacturer's delays in the delivery of photographic equipment, over six months in the case of the eye movement camera, no photographic testing of the models has yet taken place.

Publications: None

EC-00327-01 (UI-00914-01)

HEALTH RESEARCH ON HOUSING AND PLANNING CONFERENCE

CHARLES L. SENN
AMERICAN PUBLIC HEALTH ASSOCIATION
NEW YORK, NEW YORK

Objectives: An international conference on urban planning and housing as they are related to man's physical, mental and social well being.

Significant Results: The agenda, speakers and invited national and international participants were selected by the planning committee for this conference which was composed of BCEM staff and outside advisors. The meeting date was March 17-20, 1969, at Airlie House, Warrenton, Virginia.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVE, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00340-01 (UI-01056-01)	URBAN RAT POPULATION AND CONTROL MEASURES	RICHARD V. ANDREWS CREIGHTON UNIVERSITY OMAHA, NEBRASKA

Objectives: Assessment of physiological and behavioral dynamics of rat population regulators which may be of value in developing more efficient mechanisms for urban rat control.

Significant Results: A study of physiological and behavioral mechanisms which affect rat population density has been initiated. The first phase of the study involves monitoring enclosed, freely growing populations of rats for changes in behavioral and endocrine functions which operate to "set" the population level by regulating the mortality rate--birth rate--recruitment equilibrium in wild Norway rats. The study of wild rats in experimental enclosures will permit estimating the stage of population establishment and density urban rats are likely to have reached. The distribution of body sizes, sex, sexual maturity, sexual activity and frequency of pregnancy vary with density of animals in relation to their available harborage. Current evaluation of the experimental finding that "stressed" wild rodent populations produce high quantities of progesterone in addition to corticosterone is being made. Efforts will be made to exploit this finding by both increasing social disorganization in "test" rat control blocks and by supplementing natural progestins with progesterone analogs which are bait administered. It is expected that a combined poisoning--social disorganization--contraceptive program will provide for longer duration rodent control than standard poisoning practices.

Publications: None

BCEM RESEARCH GRANTS TRANSFERRED TO THE FOOD AND DRUG ADMINISTRATION

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00035-04 (UI-00307-04)	BIOSYNTHESIS OF F-2 (FUNGUS PRODUCED ESTROGEN)	C. J. MIROCHA UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA
FD-00047-08 (UI-00097-08)	HEAT INACTIVATION OF STAPHYLOCOCCUS ENTEROTOXIN	C. W. BOHRER NATIONAL CANNERS ASSOCIATION WASHINGTON, D. C.
FD-00048-08 (UI-00101-08)	PHYSIOLOGY OF THE BACTERIA IN DAIRY STARTERS	E. B. COLLINS UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA
FD-00049-13 (UI-00115-13)	FACTORS INVOLVED IN THE HEAT DAMAGE OF OILS	E. G. PERKINS UNIVERSITY OF ILLINOIS URBANA, ILLINOIS
FD-00050-08 (UI-00125-08)	WATER CONTENT AND LIPID OXIDATION IN DEHYDRATED FOODS	M. KAREL MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00051-08 (UI-00126-08)	ULTRA HIGH TEMPERATURE EFFECTS ON BACTERIAL SPORES	M. L. SPECK NORTH CAROLINA STATE UNIVERSITY RALEIGH, NORTH CAROLINA
FD-00052-07 (UI-00139-07)	GROWTH AND ACTIVITY OF PSYCHROPHILIC BACTERIA	L. D. WITTER UNIVERSITY OF ILLINOIS URBANA, ILLINOIS
FD-00053-05 (UI-00148-05)	EFFECTS OF IONIZING RADIATION ON FOOD LIPIDS	W. W. NAWAR UNIVERSITY OF MASSACHUSETTS AMHERST, MASSACHUSETTS

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00054-03 (UI-00200-03)	ANTIBIOTIC RESIDUES AND PUBLIC HEALTH	W. G. HUBER UNIVERSITY OF ILLINOIS URBANA, ILLINOIS
FD-00061-11 (UI-00087-11)	ECOLOGICAL FACTORS OF FOOD BORNE DISEASE	S. A. GOLDBLITH MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00062-08 (UI-00088-08)	LACTOSE UTILIZATION BY LACTIC STREPTOCOCCI	W. E. SANDINE OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00063-07 (UI-00090-07)	FLAVOR DEFECTS LIMITING THE USE OF UNSATURATED FATS	E. G. HAMMOND IOWA STATE UNIVERSITY AMES, IOWA
FD-00064-08 (UI-00092-08)	KINETICS AND MODE OF CHEMICAL VAPOR PHASE STERILIZATION	C. R. STUMBO UNIVERSITY OF MASSACHUSETTS AMHERST, MASSACHUSETTS
FD-00065-12 (UI-00095-12)	EFFECTS OF ENVIRONMENT ON STORED-PRODUCTS INSECTS	D. A. WILBUR KANSAS STATE UNIVERSITY MANHATTAN, KANSAS
FD-00068-09 (UI-00099-09)	CLOSTRIDIUM PERFRINGENS AS RELATED TO FOOD POISONING	D. H. STRONG UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00069-07 (UI-00100-07)	STUDIES ON SPORES OF FOOD SPOILAGE CLOSTRIDIA	H. A. FRANK UNIVERSITY OF HAWAII HONOLULU, HAWAII
FD-00071-09 (UI-00102-09)	PHYSIOLOGY AND BIOCHEMISTRY OF FRUIT RESPIRATION	H. K. PRATT UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00072-10 (UI-00106-10)	SIGNIFICANCE OF SPORE-FORMING MICROORGANISMS IN MILK	E. M. MIKOLAJCIK OHIO STATE UNIVERSITY COLUMBUS, OHIO
FD-00073-10 (UI-00107-10)	CARBONYL COMPOUNDS FROM AUTOXIDIZING FATS	R. C. LINDSAY OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00074-08 (UI-00110-08)	TOXIC CHEMICALS IN PLANTS AND THEIR RESIDUAL EFFECTS	A. J. LINCK UNIVERSITY OF MINNEAPOLIS MINNEAPOLIS, MINNESOTA
FD-00075-08 (UI-00111-08)	METABOLISM AND DISPOSITION OF INSECTICIDES IN THE FOWL	M. SHERMAN UNIVERSITY OF HAWAII HONOLULU, HAWAII
FD-00076-06 (UI-00141-06)	MECHANISM OF CHLOROPHYLL BIODEGRADATION	S. H. SCHANDERL MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN
FD-00077-06 (UI-00142-06)	HEAT INDUCED COMPOUNDS IN MILK	R. C. LINDSAY OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00078-06 (UI-00143-06)	METAL COMPLEXES AND COLOR OF CERTAIN PROCESSED FOODS	I. D. JONES NORTH CAROLINA STATE UNIVERSITY RALEIGH, NORTH CAROLINA
FD-00079-06 (UI-00145-06)	PIGMENT STUDIES IN PROCESSED GREEN VEGETABLES	F. J. FRANCIS UNIVERSITY OF MASSACHUSETTS AMHERST, MASSACHUSETTS
FD-00080-06 (UI-00146-06)	NATURAL RESISTANCE OF EGGS TO MICROBIAL CONTAMINATION	R. C. BAHER CORNELL UNIVERSITY ITHACA, NEW YORK

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00081-06 (UI-00147-06)	GROWTH AND TOXIN PRODUCTION OF FOOD-STORAGE FUNGI	U. L. DIENER AUBURN UNIVERSITY AUBURN, ALABAMA
FD-00083-05 (UI-00149-05)	DETERMINATION AND REACTIONS OF FOOD GUMS	H. D. GRAHAM UNIVERSITY OF PUERTO RICO MAYAGUEZ, P. R.
FD-00084-05 (UI-00152-05)	INTERACTIONS OF SOIL MICROORGANISMS AND HERBICIDES	ELROY A. CURL AUBURN UNIVERSITY AUBURN, ALABAMA
FD-00085-05 (UI-00154-05)	METABOLIC INJURY OF BACTERIA	M. L. SPECK NORTH CAROLINA STATE UNIVERSITY RALEIGH, NORTH CAROLINA
FD-00087-05 (UI-00159-05)	CONTROL OF SALMONELLA	G. H. SNOEYENBOS UNIVERSITY OF MASSACHUSETTS AMHERST, MASSACHUSETTS
FD-00088-05 (UI-00161-05)	THE PHYSIOLOGY OF PLANT TOLERANCE TO FUNGAL INFECTION	J. A. BOOTH NEW MEXICO STATE UNIVERSITY LAS CRUCES, NEW MEXICO
FD-00089-04 (UI-00163-04)	SURVIVAL MECHANISM OF IRRADIATED MICROORGANISMS IN FOODS	J. S. LEO OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00090-04 (UI-00165-04)	ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E IN GREEN BAY	HIROSKI SUGIYAMA UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00091-05 (UI-00169-05)	EFFECT OF LIGHT OF HIGH INTENSITY ON MICROORGANISMS	C. O. CHICHESTER UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00092-04 (UI-00170-04)	FOOD POLLUTION AND SALIVARY (VIRIDANS) STREPTOCOCCI	M. D. APPLEMAN UNIVERSITY OF SOUTHERN CALIFORNIA LOS ANGELES, CALIFORNIA
FD-00093-04 (UI-00174-04)	BACTERIAL CELL INJURY AND RECOVERY	J. Z. ORDAL UNIVERSITY OF ILLINOIS URBANA, ILLINOIS
FD-00094-04 (UI-00176-04)	PHYTOALEXINS AND PLANT DISEASE RESISTANCE	N. L. KLARMAN UNIVERSITY OF MARYLAND COLLEGE PARK, MARYLAND
FD-00095-03 (UI-00177-03)	MOLECULAR STRUCTURE OF HEAT STABLE BOTULINUM TOXIN	N. GRECZ ILLINOIS INSTITUTE OF TECHNOLOGY CHICAGO, ILLINOIS
FD-00096-04 (UI-00181-04)	RADIATION SENSITIZATION OF MICROORGANISMS	C. C. THOMAS WESTERN NEW YORK NUCLEAR RESEARCH CENTER, INCORPORATED BUFFALO, NEW YORK
FD-00097-03 (UI-00191-03)	CHANGES IN MUSCLE PROTEINS CAUSED BY MICROBIAL GROWTH	A. M. PEARSON MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN
FD-00098-03 (UI-00198-03)	HOST-PARASITE INTERACTION WITH PSEUDOMONAS SOLANACEARUM	I. W. BUDDENHAGEN UNIVERSITY OF HAWAII HONOLULU, HAWAII
FD-00100-03 (UI-00204-03)	PATHOGENESIS OF ERYSIPELOTHRIX INSIDIOSA	R. E. CORSTVET OKLAHOMA STATE UNIVERSITY OF AGRICULTURE & APPLIED SCIENCE STILLWATER, OKLAHOMA

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00103-03 (UI-00222-03)	FACTORS INFLUENCING STAPHYLOCOCCAL ENTEROTOXIGENESIS	W. W. SADLER UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA
FD-00104-03 (UI-00238-03)	MECHANISMS OF ANTIOXIDANT AND SYNERGISTIC ACTION	H. S. OLCOTT UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA
FD-00105-04 (UI-00262-04)	PROGRAM PROJECT-FOOD MICROBIOLOGY	G. F. STEWART UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA
FD-00106-04 (UI-00263-04)	FOOD INFECTIONS, TOXINS, AND ADDITIVES OF MICROBIAL ORIGIN	H. W. WALKER IOWA STATE UNIVERSITY AMES, IOWA
FD-00107-11 (UI-00266-11)	Ph LEVELS AND RELATED PROPERTIES OF PROCINE MUSCLE	E. J. BRISKEY UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00108-09 (UI-00271-09)	MILK PROTEIN CHANGES AT ELEVATED TEMPERATURE	P. N. HANSEN OHIO STATE RESEARCH FOUNDATION COLUMBUS, OHIO
FD-00109-08 (UI-00274-08)	A STUDY OF BOVINE TEAT CANALS IN HEALTH AND DISEASE	G. E. MORSE UNIVERSITY OF PENNSYLVANIA PHILADELPHIA, PENNSYLVANIA
FD-00110-07 (UI-00280-07)	DETERMINING EDIBLE QUALITY IN MEATS	J. M. JAY WAYNE STATE UNIVERSITY DETROIT, MICHIGAN
FD-00111-06 (UI-00283-06)	ENTEROCOCCI IN FROZEN VEGETABLES	J. O. MUNDT UNIVERSITY OF TENNESSEE KNOXVILLE, TENNESSEE

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00112-06 (UI-00286-06)	THERMAL DESTRUCTION OF TYPE E CLOSTRIDIUM BOTULIUM	C. W. BOHRER NATIONAL CANNERS ASSOCIATION WASHINGTON, D. C.
FD-00113-05 (UI-00289-05)	EFFECT OF PROCESSING ON NUTRITIONAL VALUE OF PROTEIN	L. R. HACKLER CORNELL UNIVERSITY ITHACA, NEW YORK
FD-00114-04 (UI-00291-04)	CLOSTRIDIUM PERFRINGENS FOOD POISONING	MITSURU NAKAMURA UNIVERSITY OF MONTANA MISSOULA, MONTANA
FD-00115-05 (UI-00293-05)	PRESERVATION BY FREEZING AND GAS HYDRATE FORMATION	O. R. FENNEMA UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00116-05 (UI-00294-05)	MICROENVIRONMENT AND DETERIORATION OF DAIRY EQUIPMENT	R. B. MAXCY UNIVERSITY OF NEBRASKA LINCOLN, NEBRASKA
FD-00117-05 (UI-00295-05)	HYDROPHILIC COLLOID INTERACTIONS IN FOODS	P. M. T. HANSEN OHIO STATE UNIVERSITY COLUMBUS, OHIO
FD-00118-04 (UI-00301-04)	ANTIBIOTIC ESSENTIAL TO A PATHOGEN'S SURVIVAL	G. W. BRUEHL WASHINGTON STATE UNIVERSITY PULLMAN, WASHINGTON
FD-00119-04 (UI-00302-04)	PROPER PROCESSING OR STORAGE CONDITIONS ON FOODS	K. HAYAKAWA RUTGERS, THE STATE UNIVERSITY NEW BRUNSWICK, NEW JERSEY
FD-00123-01 (UI-00311-01)	INCREASING THE RETENTION OF MINERAL NUTRIENTS IN CHEESE	NORMAN F. OLSON UNIVERSITY OF WISCONSIN MADISON, WISCONSIN

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00124-03 (UI-00312-03)	CLOSTRIDIUM PERFRINGENS IN VACCUM PACKED MEAT	M. SOLBERG RUTGERS, THE STATE UNIVERSITY NEW BRUNSWICK, NEW JERSEY
FD-00125-01 (UI-00317-01)	RESPIRATORY PATHWAYS IN THE LACTOBACILLACEAE	H. W. SEELEY, JR. CORNELL UNIVERSITY ITHACA, NEW YORK
FD-00126-02 (UI-00321-02)	COMPLEXES FORMED IN HEAT STERILIZED MILK PRODUCTS	H. K. WILSON UNIVERSITY OF ILLINOIS URBANA, ILLINOIS
FD-00128-02 (UI-00329-02)	STUDIES IN VIBRIO FOOD POISONING	K. FIJIWARA CHIBA UNIVERSITY OKUBO, MIRASHINO CITY CHIBA-KEN, JAPAN
FD-00130-01 (UI-00335-01)	VARIATIONS IN BACTERIAL ENDOSPORE POPULATIONS	H. W. WALKER IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY AMES, IOWA
FD-00131-01 (UI-00338-01)	101 PROBLEMS IN FOOD SCIENCE AND TECHNOLOGY	C. O. CHICHESTER UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA
FD-00132-01 (UI-00345-01)	LIPASE ACTIVITY OF MILK AND BLOOD	J. B. MICKLE OKLAHOMA STATE UNIVERSITY STILLWATER, OKLAHOMA

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00134-02 (UI-00348-02)	PESTICIDE RESISTANT FISH IN NATURAL ECOSYSTEMS	D. E. FERGUSON MISSISSIPPI STATE UNIVERSITY STATE COLLEGE, MISSISSIPPI
FD-00136-03 (UI-00364-03)	EFFECT OF FOOD MICROFLORA ON RECOVERY OF PATHOGENS	H. L. BODILY CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH BERKELEY, CALIFORNIA
FD-00137-02 (UI-00369-02)	TEMPERATURE CYCLING EFFECTS ON FOOD SAFETY AND QUALITY	J. J. POWERS UNIVERSITY OF GEORGIA ATHENS, GEORGIA
FD-00140-02 (UI-00385-02)	QUANTITATIVE ANALYSIS OF FOOD PACKAGING PROBLEMS	M. KAREL MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00141-03 (UI-00529-03)	THE MODE OF ACTION OF PECTIC ENZYMES	J. D. MACMILLAN RUTGERS, THE STATE UNIVERSITY NEW BRUNSWICK, NEW JERSEY
FD-00143-02 (UI-00626-02)	MYCOTOXINS AND THEIR DEVELOPMENT IN FOODS	E. H. MARTH UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00144-02 (UI-00643-02)	BEHAVIOR OF SALMONELLA IN DRY AND SEMI-DRY ENVIRONMENTS	J. M. GOEPFERT UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00145-01 (UI-00644-01)	VIRUS STABILITY IN SUB-LETHALLY PROCESSED FOODS	A. J. SINSKEY MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00148-02 (UI-00663-02)	ENVIRONMENTAL FACTORS IN TOXIC ALKALOID BIOSYNTHESIS	V. V. RENDIG UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA
FD-00149-08 (UI-00678-08)	SANITATION OF FREEZE-DRIED FOODS	S. A. GOLDBLITH MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00150-06 (UI-00680-06)	VOLATILE FOOD CONSTITUENTS OF BIOLOGICAL IMPORTANCE	E. L. WICK MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00152-03 (UI-00686-03)	TEMPERATURE EFFECT ON C. BOTULIUM TOXIN PRODUCTION IN FISH	P. J. PACE MILWAUKEE HEALTH DEPARTMENT MILWAUKEE, WISCONSIN
FD-00153-04 (UI-00687-04)	PHAGE TYPING OF PSYCHROPHILES	ROBERT E. LEVIN UNIVERSITY OF MASSACHUSETTS AMHERST, MASSACHUSETTS
FD-00154-03 (UI-00688-03)	SOIL MICROFLORAL ANTIBIOSES OF FLATOXIC CARCINOGENS	J. LYND OKLAHOMA STATE UNIVERSITY STILLWATER, OKLAHOMA
FD-00155-02 (UI-00698-02)	TOXOGENIC AND PATHOGENIC FUNGI IN FOOD PRODUCTS	J. C. AYRES UNIVERSITY OF GEORGIA ATHENS, GEORGIA

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00156-02 (UI-00712-02)	TRANSPORT PHENOMENA ASSOCIATED WITH FREEZE-DRYING	J. E. SUNDERLAND NORTH CAROLINA STATE UNIVERSITY RALEIGH, NORTH CAROLINA
FD-00157-02 (UI-00713-02)	ISOLATION OF ANTI-THIAMINE FACTORS IN HAWAII FISH	D. M. HILKER UNIVERSITY OF HAWAII HONOLULU, HAWAII
FD-00158-01 (UI-00715-01)	SYMPOSIUM: PHYSIOLOGY AND BIOCHEMISTRY OF MUSCLE AS A FOOD II	E. J. BRISKEY UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00159-01 (UI-00720-01)	PHYSIOLOGICAL STRESS AS A CAUSE OF ABNORMAL MILK	G. H. STOTT UNIVERSITY OF ARIZONA TUCSON, ARIZONA
FD-00160-02 (UI-00743-02)	DRY HEAT THERMAL INJURY IN MICROORGANISMS	J. J. IANDOLO KANSAS STATE UNIVERSITY MANHATTAN, KANSAS
FD-00161-01 (UI-00733-01)	ANTIMICROBIAL PROPERTIES OF BOVINE MILK SERUM	E. M. MIKOLAJCIK OHIO STATE UNIVERSITY RESEARCH FOUNDATION COLUMBUS, OHIO
FD-00163-02 (UI-00747-02)	DETERMINING STAPHYLOCOCCAL ENTEROTOXIN IN FOOD	L. G. HARMON MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00164-01 (UI-00748-01)	FACTORS IN STAPHYLOCOCCAL ENTEROTOXIN PRODUCTION	G. H. RICHARDSON UTAH STATE UNIVERSITY LOGAN, UTAH
FD-00165-14 (UI-00783-14)	IMPROVEMENT IN SANITATION BY IONIZING RADIATION	S. A. GOLDBLITH MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00166-01 (UI-00784-01)	PREDICTION OF DIELECTRIC PROPERTIES OF FOODS	S. A. GOLDBLITH MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00168-01 (UI-00795-01)	STAPHYLOCOCCAL LYSOZYME	J. M. JAY WAYNE STATE UNIVERSITY DETROIT, MICHIGAN
FD-00169-01 (UI-00811-01)	CONTROL OF CLOSTRIDIUM BOTULINUM IN FISH PROCESSING PLANTS	K. A. ITO NATIONAL CANNERS ASSOCIATION WASHINGTON, D. C.
FD-00172-01 (UI-00861-01)	ANTIBIOTICS IN ANIMAL TISSUE AND PRODUCTS	S. E. KATZ RUTGERS, THE STATE UNIVERSITY NEW BRUNSWICK, NEW JERSEY
FD-00173-01 (UI-00862-01)	CARBONYL ACCUMULATION DURING BROWNING OF FRUIT	C. O. CHICHESTER UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00174-01 (UI-00863-01)	SALMONELLAE AND SHIGELLAE VIABILITY IN DRIED FOODS	T. P. LABUZA MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00176-01 (UI-00892-01)	MYCOTOXINS IN FEEDS AND FOODS	C. M. CHRISTENSEN UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA
FD-00177-01 (UI-00896-01)	STUDIES ON ANAEROBIC BACTERIA (GENUS CLOSTRIDIUM)	L. S. McCLUNG INDIANA UNIVERSITY FOUNDATION BLOOMINGTON, INDIANA
FD-00178-01 (UI-00956-01)	EFFECT OF FOOD COMPONENTS ON SPORE-FORMING BACTERIA	F. D. BUSTA UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA
FD-00179-01 (UI-00964-01)	CONFERENCE ON MICROBIOLOGICAL QUALITIES OF FISHERY PRODUCTS	H. D. GRAHAM UNIVERSITY OF PUERTO RICO MAYAGUEZ, PUERTO RICO
FD-00180-01 (UI-00965-01)	STUDIES ON A THERMOPHILIC AEROBIC BACTERIUM	MARION L. FIELDS UNIVERSITY OF MISSOURI COLUMBIA, MISSOURI
FD-00209-08 (UI-00112-08)	ISOLATION AND IDENTIFICATION OF MEAT FLAVORED COMPONENTS	A. M. PEARSON MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN
FD-00210-02 (UI-00344-02)	PHYSICAL-CHEMICAL EQUILIBRIA IN PROCESSED FOODS	J. R. BRUNNER MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00212-09 (UI-00113-09)	FATE AND MECHANISM OF ACTION OF PRESCRIBED HERBICIDES	D. E. DAVIS AUBURN UNIVERSITY AUBURN, ALABAMA
FD-00213-08 (UI-00114-08)	PREPARATION OF A FOOD ADDITIVES CODEX	P. E. JOHNSON NATIONAL ACADEMY OF SCIENCE WASHINGTON, D. C.
FD-00214-08 (UI-00117-08)	MICROBIAL CONTAMINATION OF FROZEN VEGETABLES	D. F. SPLITTSTOESSER CORNELL UNIVERSITY ITHACA, NEW YORK
FD-00215-08 (UI-00119-08)	CHARACTERIZATION OF COMPOUNDS IN CHEDDAR CHEESE	L. M. LIBBEY OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00216-07 (UI-00120-07)	MICROBIOLOGICAL LYSIS OF FUNGI	MARTIN ALEXANDER CORNELL UNIVERSITY ITHACA, NEW YORK
FD-00217-07 (UI-00124-07)	MASTITIS SCREENING TESTS FOR MIXED HARD MILK	D. S. POSTLE UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00218-07 (UI-00129-07)	CHEMISTRY OF HYDRATIVE CHANGES IN POST-MORTEM MUSCLE	A. F. ANGLEMIER OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00219-06 (UI-00130-06)	SEPARATION AND CLASSIFICATION OF SMOKE COMPONENTS	L. J. BRATZLER MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00220-06 (UI-00131-06)	CHEMICAL AND BACTERIOLOGICAL CHANGES IN FROZEN EGGS	L. E. DAWSON MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN
FD-00221-06 (UI-00136-06)	DENATURATION OF LIPO-PROTEINS IN EGG YOLK	OWEN FENNEMA UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00222-06 (UI-00137-06)	METABOLISM OF CYCLOPROPENOID FATTY ACIDS	MITCHELL G. VAVICH UNIVERSITY OF ARIZONA TUCSON, ARIZONA
FD-00281-06 (UI-00278-06)	A STUDY OF THE OXIDATION OF LIPIDS IN FOODS	LEONARD W. AURAND NORTH CAROLINA STATE UNIVERSITY RALEIGH, NORTH CAROLINA
FD-00284-03 (UI-00162-03)	THE DEGRADATION PRODUCTS OF HERBICIDES	PROSANTO BISWAS TUSKEGEE INSTITUTE TUSKEGEE, ALABAMA
FD-00285-02 (UI-00248-02)	MECHANISMS OF LOW TEMPERATURE GROWTH OF BACTERIA ON FOODS	J. LISTON UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON
FD-00286-09 (UI-00267-09)	CHARACTERIZATION OF VOLATILE SUBSTANCE IN FOODS	WALTER JENNINGS UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA
FD-00287-08 (UI-00268-08)	FUNGITOXIC RESIDUES IN SOIL WATER AND PLANTS	MALCOLM E. CORDON OREGON STATE UNIVERSITY CORVALLIS, OREGON

GRANT NO.	TITLE OF PROJECT	PRINCIPAL INVESTIGATOR & LOCATION
FD-00288-01 (UI-00318-01)	EFFECT OF DEHYDROGENASE ON STAPHYLOCOCCAL PERSISTENCE	MOSTAFA K. HAMDY UNIVERSITY OF GEORGIA ATHENS, GEORGIA
FD-00289-01 (UI-00393-01)	SYMPOSIUM ON FOODS: CARBOHYDRATES AND THEIR ROLES	HAROLD W. SCHULTZ OREGON STATE UNIVERSITY CORVALLIS, OREGON
FD-00290-07 (UI-00679-07)	COMPILATION OF DATA ON FEED COMPOSITION	LORIN E. HARRIS UTAH STATE UNIVERSITY LOGAN, UTAH

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00002-04 (UI-01001-04)	ACCIDENT PREVENTION RESEARCH	NORMAN W. HEIMSTRA UNIVERSITY OF SOUTH DAKOTA VERMILLION, SOUTH DAKOTA

Objectives: To produce psychologists who are well trained and who have developed an active interest and research capabilities in the field of injury control. Individuals involved in this program will meet all the requirements for a Ph.D. degree in psychology, and through course work and research experience will be trained for a career in injury control research. Training in this area will be accomplished through (1) a continuing seminar dealing with topics in the area of injury control, (2) research experience by the trainees on projects in the injury control area and (3) site visits by trainees to other laboratories engaged in this type of research.

Publications: Warner, Harold D. "Effects of Intermittent Noise on Human Target Detection," Human Factors; 11(3):245-250, 1969, University of South Dakota.

EC-00003-04 (UI-01002-04)	ACCIDENT PREVENTION (TRANSPORTATION SAFETY)	THOMAS H. ROCKWELL OHIO STATE UNIVERSITY COLUMBUS, OHIO

Objectives: This training program is intended to produce qualified researchers to work in the general problem area of transportation systems safety and reliability. The program is designed so that the trainees pursue a M.S. Ph.D. degree in Industrial Engineering, Civil Engineering, Preventive Medicine, Psychology, or other related areas by satisfying the normal degree requirements while taking a supplementary course each quarter in transportation systems accident prevention. This seminar course includes lectures on the applicable techniques from the many disciplines which may be of use in solving transportation systems problems, discussions of current and potential problem areas within our transportation systems, lectures by the nation's outstanding researchers dealing with transportation systems, and field trips to those governmental,

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION

EC-00003-04 (Continued)

industrial, and private research laboratories which are centers of research in this area. Each student is given the opportunity to work in the overall departmental research projects and is required to do his thesis or dissertation research in the general area of transportation systems safety and reliability. In addition, students work on class projects both individually and in interdisciplinary groups.

EC-00004-03 (UI-01003-03)

PREDOCTORAL RESEARCH TRAINING IN ACCIDENT CAUSATION

HARRY W. CASE
UNIVERSITY OF CALIFORNIA
LOS ANGELES, CALIFORNIA

Objectives: To provide a five-year predoctoral training program in understanding transportation accident causation and resulting injuries, and to fulfill the nationwide needs of manpower trained in the field. For trainees in the first year of the program, a graduate seminar on "Current Developments in Transportation Safety" was given in the academic year 1968-1969. The seminar was well attended by the trainees and other graduate students. The trainees in the second year of the program have been assigned to accident research projects at UCLA which reflect individual interests. Twelve students are expected to continue the program in 1969-1970.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00013-09 (UI-01025-09)	ENVIRONMENTAL HEALTH	MORTON S. HILBERT UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN

Objectives: To provide research training and study in several major areas of environmental health related to man's total environment. This program involves many interrelated disciplines which encompass the physical, biological and social sciences. Specific areas of research and training available to students in the Department of Environmental Health involve air, water, food, community development and planning, hospital and institutional environments, radiological health, and environmental health administration.

EC-00014-09 (UI-01026-09)	SANITARY & ENVIRONMENTAL HEALTH ENGINEERING	HAROLD B. GOTAAS NORTHWESTERN UNIVERSITY EVANSTON, ILLINOIS

Objectives: The rapid pace of technological developments, population growth, and urbanization are combining to increase the magnitude and complexities of environmental health problems. There is an acute shortage in the number of people with the necessary training to cope with environmental health problems on a highly professional level. This shortage results from the relatively recent implementation of the gestalt concept in environmental health and the "instant" demands created by problems associated with urbanization.

GRANT NO.	TITLE OF PROJECT, RESUME & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION

EC-00014-09 (Continued)

The current research training program is based on the gestalt concept and provides exposure of graduate students to research on significant problems in environmental health engineering.

It is hoped that future personnel may be trained to have an interest in and an aptitude for basic research and translation of research results to the design of our environment, for only in this manner can the development of the field be sustained and accelerated. The individuals receiving this training would ideally be proficient both in research and in the analysis and the synthesis of systems and processes important to the understanding and control of the environment as it relates to health. Four of 40 full-time graduate students in environmental health engineering are supported by this grant currently.

EC-00017-07
(UI-01034-07)

ENVIRONMENTAL HEALTH SCIENCES

GEORGE W. REID
UNIVERSITY OF OKLAHOMA
NORMAN, OKLAHOMA

Objectives: A program in environmental health sciences and engineering at both the master and doctoral level, with instruction and research in the areas of sanitary science, sanitary biology, sanitary chemistry, and sanitary engineering. Of concern are the "generalist" and "specialist" with both types accommodated by means of a core plus elective concept which will put staff and students in contact with the scientific as well as the engineering aspect of environmental health.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00019-04 (UI-01040-04)	URBAN PLANNING & ENVIRONMENTAL HEALTH	GEORGE S. DUGGAR UNIVERSITY OF PITTSBURGH PITTSBURGH, PENNSYLVANIA

Objectives: This is a joint program between the Department of Urban Affairs in the Graduate School of Public and International Affairs and the program in Environmental Health in the Graduate School of Public Health at the University. The purpose is to train scholars, educators and research administrators to the doctoral level in a program that assures their adequacy in both these closely related fields, with the equivalent of a "Major" in one and a "Minor" in the other. Also, the doctoral research is to be on subject matter of relevance to the two fields. This program is intended to reduce the present lack of professional appreciation of the many links between the two fields and to supply the trained talent which will provide research literature to sustain future professional education and practice in the area of joint interest.

EC-00021-05 (UI-01046-05)	ENVIRONMENTAL HEALTH	EARNEST F. GLOYNA UNIVERSITY OF TEXAS AUSTIN, TEXAS

Objectives: This training grant is supporting 25 graduate students in the fields of Environmental Health Engineering, Atmospheric Science, Zoology, Chemistry, Microbiology, Botany, Geology and Civil Engineering. The grant presents the faculty and students with an opportunity to study problems affecting man's environment and to share their ideas as to the most realistic approaches to solutions of the problems. The grant permits student research associated with the interactions among the elements of our environment (soil and earth materials, water, air, living things, radiation and structures). This interdisciplinary effort involves work in selected areas which embraces five degree programs in the science disciplines.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00022-03 (UI-01048-03)	NEIGHBORHOOD ENVIRONMENTAL HEALTH PLANNING	ALLAN G. FELDT CORNELL UNIVERSITY ITHACA, NEW YORK

Objectives: To provide a number of persons with advanced degrees in planning or related areas with a strong background in the problems and experience of planning for subcommunity populations such as those generally called neighborhoods or housing projects. Three to four courses together with other course work in general environmental health planning, coupled with advanced work in other graduate fields relevant to the neighborhood, provide the basis for bringing together knowledge of theory and findings in the social sciences with similar materials in the engineering and health sciences and the architectural and planning fields. Several fellowships are also provided for selected students showing special promise in these studies and assistance is provided in seeking research funds for dissertation research on the neighborhood and the residential subcommunity.

EC-00023-03 (UI-01049-03)	ENVIRONMENTAL HEALTH	JON C. LIEBMAN JOHNS HOPKINS UNIVERSITY BALTIMORE, MARYLAND

Objectives: This program provides doctorate level training for advanced students in the application of operations research methods to environmental health and engineering problems. Participants are principally sanitary engineers and persons desiring to enter health work in the broad area of environmental hygiene including essential sanitary services to communities. In addition to traditional training in these fields, students in the program receive additional training in economics, computer techniques, statistics and probability mathematics, mathematical optimization, and other fields of operations research. This background will enable them to apply analytical techniques in the solution of problems in solid wastes, epidemiology, vector control, analysis of health services, and other environmental health fields.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00025-03 (UI-01052-03)	ENVIRONMENTAL HEALTH & SYSTEMS ENGINEERING	J. VENN LEEDS, JR. RICE UNIVERSITY HOUSTON, TEXAS

Objectives: Systems theory has been an active research area for many years and the approach has been applied in many fields. However, the systems engineer is not usually introduced to environmental health problems nor is the person trained in environmental health normally introduced to systems engineering. The program assumes that people trained in both environmental health and systems engineering can solve significant problems in environmental health better than those not trained in both areas. In systems engineering one must have a high degree of competence in topics which include mathematics, control theory, optimization theory, mathematical modeling. In environmental health one must develop a similar level of competence in areas which include transport phenomena, biochemistry, microbiology, and physiology. To develop persons with capabilities in both areas, the program takes people whose prior training is in either area. The student will then, at the graduate level, develop competence as necessary in both areas. His doctoral dissertation will be the solution of actual problems in environmental health, regardless of his background.

EC-00027-07 (UI-01059-07)	TRAINING PROGRAM IN ENVIRONMENTAL HEALTH PLANNING	BARCLAY G. JONES CORNELL UNIVERSITY ITHACA, NEW YROK

Objectives: To train researchers in environmental health planning. In order to become able to conduct meaningful research, a student must acquire a solid competence in quantitative methods by which hypotheses are framed, tested, and evaluated. These quantitative methods are the tools with which theories are formed and basic theoretical contributions are made. The relevant bodies of

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION

EC-00027-07 (Continued)

theory that the student must master are: (1) those concerned with the spatial distribution of populations and activities over the geographical surface of a metropolitan area or a region, and (2) the theory of the planning process. These basic tools must then be related to environmental health problems and the student must be made familiar with the nature of these problems, current research with respect to them, and current applications of quantitative methods to the advancement of the theory and the solution of the problems. The training program, therefore, has as its first emphasis the development of skills in the uses of quantitative methods. Its second emphasis is developing within the student a mastery of the current theory of cities and regions and the current theory of the planning process. The third emphasis is to make the student thoroughly familiar with the field of environmental health planning and current work that is going on in this field.

EC-00030-02
(UI-01064-02)

ENVIRONMENTAL MEASUREMENTS

EDWARD A. BOETTNER
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

Objectives: The proposed program is specifically designed to provide specialized training in depth for qualified chemists in the physicochemical measurements of environmental quality. The program is based on a unified course curriculum covering the analytical chemistry of environmental sampling and analysis and research studies on advanced automated measurement systems and remote sensing techniques. Students enrolled in this program may work for M.S. and Ph.D. degrees in Environmental Health Sciences or in Industrial Health with a major in Environmental Measurements and a minor in Chemistry or Physics. Graduates of this program are "environmental analysts," trained in the measurements of the quality of urban and industrial environments. Present training activities show that the proposed program will attract the highly qualified science students.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00035-09 (UI-01029-09)	ENVIRONMENTAL HEALTH	HERBERT A. BEVIS UNIVERSITY OF FLORIDA GAINESVILLE, FLORIDA

Objectives: The objective of this program is to improve and expand graduate education and research training for environmental engineers and allied scientists. Special emphasis is placed upon interdisciplinary coordination and cooperation with related scientific fields to bring to bear all available resources upon the problems affecting man's health and well-being.

A comprehensive program in environmental engineering has been developed during the last two decades. Areas of specialization now include air resources, environmental biology, radiological health, solid wastes, water chemistry, water resources management, water supply and pollution control, and applications of systems analysis to environmental health problems. A broad program in environmental engineering is available for students not wishing to specialize in one of these fields. An increasing number of students from the basic sciences and other branches of engineering are now minoring in environmental engineering as a result of a concentrated effort to increase interdisciplinary training.

EC-00087-03 (UI-01007-03)	MULTIPHASIC RESEARCH TRAINING IN INJURY CONTROL	JACK K. WICKSTROM TULANE UNIVERSITY NEW ORLEANS, LOUISIANA

Objectives: This program is designed to acquaint graduate students in the field of medicine and engineering with the problems related to research in injury control and to stimulate interest in the University community and broader community in injury causation, handling and treatment. Emphasis is placed in the direction of early handling, care and diagnosis of injury. Lecturers in the Distingushed Lecture Series are selected for expertise in these fields.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00087-03 (Continued)	The training of ambulance crews, emergency room personnel, procedures and facilities, ambulance design and coordination of fleets-all are fields of great importance and of potential gain. As the number of trainees increases, efforts will be made to involve more medical science departments so that an engineering perfusion will take place in the research of these departments.	
EC-00089-01 (UI-01072-01)	SYSTEMS SAFETY ENGINEERING	RICHARD G. PEARSON NORTH CAROLINA STATE UNIVERSITY RALEIGH, NORTH CAROLINA

Objectives: The Systems Safety Engineering Program will be oriented around a total systems approach and will attempt to embrace the many and diverse aspects of "the safety program" by cutting across relevant disciplines. The scope of the program will be broad, including, for example, the subjects of accident prevention, environmental health, human performance, safety design, experimental and epidemiological research, accident-injury correlation, and investigation technique. The primary goal of the program will be the training of individuals at the doctoral and post-doctoral level who would be interested in and capable of conducing or directing research programs using the engineering systems approach. These graduates will emerge with a background that will permit them to apply the system philosophy to a broad spectum of systems safety problems. The application areas may include agricultural, construction, home, hospital, manufacturing and transportation systems. While the program anticipates a strong applied research effort, this will not preclude interest in basic research.

BCEM TRAINING GRANTS TRANSFERRED TO THE FOOD AND DRUG ADMINISTRATION

GRANT NO.	TITLE OF PROJECT	PROGRAM DIRECTOR & LOCATION
FD-00001-09 (UI-01031-09)	FOOD SCIENCE, FOOD MICROBIOLOGY, CHEMISTRY & ENGINEERING	B.S. SCHWEIGERT MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN
FD-00002-08 (UI-01032-08)	FOOD CHEMISTRY & MICROBIOLOGY	R. F. HOLLAND CORNELL UNIVERSITY ITHACA, NEW YORK
FD-00003-07 (UI-01033-07)	FOOD SCIENCE & TECHNOLOGY	SAMUEL A. GOLDBLITH MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS
FD-00004-07 (UI-01036-07)	EFFECT OF PROCESSING AND ENVIRONMENT ON FOOD COMPONENTS	STEWART L. TUCKEY UNIVERSITY OF ILLINOIS URBANA, ILLINOIS
FD-00005-04 (UI-01043-04)	FOOD SCIENCE	HARRY E. SNYDER IOWA STATE UNIVERSITY AMES, IOWA
FD-00006-04 (UI-01044-04)	ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION	JOHN J. POWERS UNIVERSITY OF GEORGIA ATHENS, GEORGIA
FD-00007-03 (UI-01047-03)	FOOD CHEMISTRY & MICROBIOLOGY	ROBERT M. GRODNER LOUISIANA STATE UNIVERSITY BATON ROUGE, LOUISIANA
FD-00008-03 (UI-01053-03)	FOOD SCIENCE & TECHNOLOGY	CLINTON O. CHICHESTER UNIVERSITY OF CALIFORNIA DAVIS, CALIFORNIA

GRANT NO.	TITLE OF PROJECT	PROGRAM DIRECTOR & LOCATION
FD-00009-03 (UI-01054-03)	FOOD TOXICOLOGY	HAROLD E. CALBERT UNIVERSITY OF WISCONSIN MADISON, WISCONSIN
FD-00010-01 (UI-01086-01)	FOOD PROTECTION AND TOXICOLOGY	HAROLD W. SCHULTZ OREGON STATE UNIVERSITY CORVALLIS, OREGON

FELLOWSHIPS

FELLOW/TITLE OF RESEARCH	GRANT NUMBER	FIELD OF INTEREST	INSTITUTION & LOCATION
Program: BCEM-Predoctoral			
Soffer, Louis F.	EC-22,329-02	Accident Prevention	Drexel Institute of Technology Philadelphia, Pennsylvania
Title: Accident Prevention-An Environmental Approach			
Borland, Barry L.	EC-34,007-03	Health Related Social Research	University of Missouri Columbia, Missouri
Title: Social Epidemiology of Accidents Involving Children			
Nielsen, Stephen A.	EC-40,152-02	Biochemistry	Florida State University Tallahassee, Florida
Title: Study of Trace Metal Accumulation in Oysters			
Harris, Geraldine E.	EC-40,686-02	Bacteriology	Wayne State University Detroit, Michigan
Title: Physico-Chemical Properties of Spoiled Meat Proteins			
Barden, Ned T.	EC-40,799-02	Food Microbiology	University of Wisconsin Madison, Wisconsin
Title: Methodology of Salmonella Detection			
Moeller, Theodore W.	EC-42,748-01	Food Technology	Michigan State University East Lansing, Michigan
Title: Concord Grape Essence, Strength and Composition			

FELLOWSHIPS

FELLOW/TITLE OF RESEARCH	GRANT NUMBER	FIELD OF INTEREST	INSTITUTION & LOCATION
Program: BCEM-Predoctoral (Continued)			
Honea, Franklin I.	EC-43,100-01	Chemical Engineering	University of Denver Denver, Colorado
Title: Study of Particles in Combustion of Waste Products			
Program: BCEM-Postdoctoral			
Markel, Raymond P.	EC-34,226-01	Ecological Physiology	Marine Biological Laboratory Woods Hole, Massachusetts
Title: Effects of Thermal Effluent on Cape Cod Canal Ecology			
Sutton, David L.	EC-40,505-01	Physiology of Aquatic Plants	U. S. Department of Agriculture Ft. Lauderdale, Florida
Title: Absorption of Herbicides by Submersed Aquatic Plants			
Program: BCEM-Special			
Rhoden, Richard A.	EC-44,453-01	Toxicology	Drexel Institute of Technology Philadelphia, Pennsylvania
Title: Hydrocarbon Inhalation & Elevated Blood Epinephrine Levels			
DesRosiers, Paul E.	EC-44,721-01	Environmental Engineering	University of Massachusetts Amherst, Massachusetts
Title: Removal of Herbicides by Reverse Osmosis			

BUREAU OF OCCUPATIONAL SAFETY AND HEALTH

Functional Statement

Plans and conducts a comprehensive program of demonstration and technical assistance to governmental agencies, professional groups, universities, labor, industry, and health-related organizations for improvement of the health and safety of the working population. Conducts studies, field investigations, and demonstrations for the detection and control of occupational and occupation-related disease and injury. Collects and analyzes data on the health status of the working population and on industrial materials and processes currently in use, or which may be coming into use. Develops criteria for standards for safe and healthful working environment. Directs studies on the economic and social consequences of occupational and occupation-related diseases and injuries and promotes occupational safety and health programs in State and local agencies.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00157-11 (UI-00397-11)	CLINICAL AND LABORATORY STUDIES OF METAL SENSITIVITY	M. H. SAMITZ UNIVERSITY OF PENNSYLVANIA PHILADELPHIA, PENNSYLVANIA

Objectives: To expand studies on the diffusion of metallic ions through the skin, to study the chemical reactions of chromium, nickel, cobalt, and mercury ions with skin proteins, mucopolysaccharides and synthetic polypeptides, and to evaluate, in guinea pigs, the immunological properties of antigens prepared in vitro. Possible preventive and curative effects of metal inactivating agents will be tested against nickel and mercury compounds. Chemical, physiological and radioactive tracer techniques will be used.

Significant Results: In the paper "Ascorbic Acid in the Prevention and Treatment of Toxic Effects from Chromates (Acta Derm-venereol. in press), a review was made of experimental data on the uses of ascorbic acid in laboratory animals for the prevention and treatment of systemic chromate intoxication and skin ulcers, and for the prevention of allergic eczematous dermatitis due to chromates. The applicability of these findings in industrial exposure was demonstrated.

This experimental model was expanded to include studies on the effect of ascorbic acid administered intramuscularly and by mouth in preventing intradermal response to Cr^6 in sensitized guinea pigs (to be submitted for publication).

Methods to study the penetration of chromium compounds through human epidermis were previously reported. Diffusion of nickel and mercury compounds through the skin are now being studied with essentially the same technique as employed with chromium.

A technique for the consistent production of delayed hypersensitivity in guinea pigs was developed. This technique for inducing sensitization has greatly increased the success rate employing dichromate and has, for the first time, allowed consistent

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00157-11 (Continued)

achievement of sensitivity in animals using a trivalent salt. This technique is now being used as a model to study other metal sensitizers such as nickel, mercury and cobalt.

The initial chemical reactions of allergic response to chromium have been defined: Chemical studies on the interactions of chromium and skin components showed that hexavalent chromium was able to oxidize several components of the skin and that trivalent chromium was bound by many components of the skin. Experimental data on chromium-protein interactions showed that soluble skin proteins bind chromium from solutions of either the hexavalent, or trivalent forms; more chromium is bound from solutions of the trivalent compounds. Saturation of the binding sites on the protein molecule was achieved with solutions of trivalent chromium at concentrations of 1.0×10^{-3} to 3.0×10^{-3}M; this saturation value corresponds to 0.106 mg Cr/g protein. In the binding of chromium, free carboxyl groups are involved to a greater extent than free amino groups.

Additional studies to define the protein-hapten conjugation are in progress (Mechanisms from Chromium Allergy: In Vitro Antigen Formation). Data derived from studies with chromium will be used as a model to study allergic contact dermatitis to nickel and mercury.

Publications: Gross, P. R., Katz, S. A., and Samitz, M. H., "Sensitization of Guinea Pigs to Chromium Salts," The Journal of Investigative Dermatology, 50, No. 5, pp 424-427, (1968), University of Pennsylvania, Philadelphia.

Scheiner, D. M., Katz, S. A. and Samitz, M. H., "Ascorbic Acid in the Prevention of Chrome Dermatitis," Arch. Env. Hlth., 17, pp 44-45, University of Pennsylvania, Philadelphia.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00158-10 (UI-00403-10)	ABSORPTION AND EXCRETION OF MERCURY IN MAN	LEONARD J. GOLDWATER COLUMBIA UNIVERSITY NEW YORK, NEW YORK

Objectives: The aims of this project are many. The studies of the mercury content of common dietary items will be extended to include food stuffs obtained outside the U.S.A. Studies will be continued on the partition of blood mercury between cells and plasma and attempt to isolate and identify mercury compounds present in blood and urine. A study will be made of routes of excretion other than urine such as stools, saliva, sweat and breath from exposed and unexposed persons, as well as tissues taken at autopsy for which a successful micro-analytical method has been developed. One major objective is to study the excretion of mercury in cases where toxic manifestations of mercurialism are evident. Some work has been done in Yugoslavia and there has been some arrangements made for studies in a Peruvian mine. About 70 men working in mercury processing plants are available at all times for study. Patients at the Neurological Institute of Columbia-Presbyterian Medical Center who receive Hg^{197} or Hg^{203} are available for excretion studies. N-acetyl-dipenicillamine and other chelating compounds will be tested for their effects on assisting mercury excretion. The excretion of coproporphyrin and delta-amino-levulinic acid are indicator compounds for increased mercury absorption as well as certain enzymes characteristic of kidney function will be studied. Work will continue on the development of analytical methods including possible adaptation of methods developed to automatic analysis.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: Jacobs, M., Yamaguchi, S., Goldwater, L. and Gilbert, H., "Determination of Mercury in Blood," 21, No. 6, American Industrial Hygiene Association Journal, pp 475-480, Columbia University, New York.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00159-05 (UI-00435-05	PHYSIOLOGICAL STUDIES ON BYSSINOSIS	AREND BOUHUYS THE JOHN B. PIERCE FOUNDATION OF CONNECTICUT, INC. NEW HAVEN, CONNECTICUT

Objectives: The aim of this project is to study byssinosis from four different aspects: (1) Elucidating the mechanism whereby it causes bronchoconstriction. (2) Attempting to isolate the pharmacological agent causing bronchoconstriction. (3) Studying long-term effects of byssinosis in cotton mill workers. (4) Correlating dust density with physiological effects to improve control mechanisms.

Significant Results: These studies, which started in 1963, have provided several items of new information:

1. The mechanism of action of textile dusts on the airways in man have been described.

2. The part of the cotton plant which contains the pharmacological agent(s) which is (are) responsible for the acute symptoms of byssinosis in textile workers has been identified.

3. Certain pharmacological properties of this agent or agents have been established and work is being done to purify the toxic substances involved, in an effort to identify them.

4. Pharmacological studies have been made on the responses of airways in man and in guinea pigs, and these studies are leading to new concepts on the factors which determine individual sensitivity to inhaled agents.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00159-05 (Continued)

5. It has been established that disabling byssinosis occurs among textile workers in the United States, and results have been published on the first systematic epidemiological studies on the prevalence of byssinosis in U.S. cotton mill workers.

6. A population study has been performed in hemp workers in Spain, and the results on that study have shown that byssinosis can be a severely disabling disease in a large proportion of textile workers, if the environmental conditions are sufficiently poor.

It is believed that these studies have practical significance for our understanding of respiratory disease among cotton textile workers, and have yielded data which can be used in practical programs to prevent this disease in industry. Byssinosis is a unique example of respiratory disease where the acute airway response to a dusty environment can be used to predict the eventual development of chronic lung disease. Studies have apparently helped to generate interest in byssinosis, and it is anticipated that practical steps toward control of this disease will soon be undertaken by the industry; in fact, some of this work may already be well underway. The methods developed under this grant can be used to assess the effectiveness of engineering efforts to control dust in textile mills.

Apart from the direct significance of findings for the health of the textile workers, it is believed that they also are significant in that they have increased the understanding of events in lung tissue and airways during inhalation of a noxious dust. The biochemical and physiological mechanisms involved in this response will probably be important for the study of other lung diseases, occupational as well as non-occupational. For instance, studies on byssinosis have increased the knowledge of what happens when people experience narrowing of small or large airways under the influence of textile dust. A quite similar physiological mechanism of airways narrowing occurs in bronchial asthma, a widely prevalent disease. It is believed that these

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studies have contributed to improvement in the methods used to detect even slight degrees of airway narrowing of this kind, and these methods have already been important in the study of drugs which are used to combat airway narrowing, both in asthma and in byssinosis.

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Bouhuys, A. and van de Woestijne, Karel P., "A Versatile Body Plethysmograph with Waterless Spirometer," Proceedings of the International Union of Physiological Sciences. VII.

EC-00160-04 (UI-00440-04)

ASBESTOS EXPOSURE AND CANCER IN THE GENERAL POPULATION

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NEW YORK, NEW YORK

Objectives: This project has two stated aims: (1) determination of the frequency of occurrence and number of asbestos fibers present in the lungs of a sampling of a general urban population, and collection of data concerning these persons including age, occupation, residence and smoking habits, and (2) determination of any association between occurrence and relative number of asbestos fibers present and presence of neoplasia or other disease processes among the studied population. Methods have been standardized. Autopsy material has been collected from three hospitals (Mt. Sinai, Elmhurst City in Queens and Bronx Veterans Administration), a total of 1,032 autopsies have been referred to Dr. Selikoff for study. This represents a little over 10 months work. Sections are taken from seven different sites in each lung, and sections from diaphragm, right main bronchus, pleura and abnormal areas, as well as smears of lung tissue fluid were also made, according to the suggestions of the Working Group on Asbestos and Cancer of the International Union Against Cancer. Methods of processing have been studied and a technique of stacking the seven sections of lung from the specified areas, each 25 micra in thickness, ashing and study with phase microscopy at "high power" appears best according to the investigators. It

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appears that none of the seven sites studied showed a greater concentration of asbestos fibers than another. All clinical data on each case are reviewed and autopsy protocol and diagnoses obtained and utilized. Interviewers are especially trained, use a special form, and attempts are made to avoid bias. Questions relate to residence history, occupational history in depth, family occupations, union membership, exposure to asbestos, direct or indirect, and to other mineral materials. Ancillary studies include mineralogical analysis and identification, using a variety of techniques, spectrographic analysis of lung tissue for trace elements and some epidemiologic information. All of this data will be coded and placed on IBM punch cards and transferred to tape for computer analysis. The first phase of the analysis is to determine distribution of subjects and relative amounts of asbestos; the latter will be studied in relation to occupation, age, etc. No results are presented regarding incidence of asbestos bodies in the autopsied population to date. Interview data are likewise not yet correlated nor results presented.

Significant Results: Important practical perspectives for the control of community and environmental hazards of asbestos are becoming evident as the result of this research.

Three thousand consecutive deaths of individuals coming to autopsy in New York City have been studied. In each, much data have been collected; personal, residential and life-time occupational. At each autopsy, too, a section of the lung has been taken and examined for the presence or absence of asbestos bodies. These were found in 45%. In an auxiliary study of a sample of these autopsies by electron microscopy, characteristic asbestos fibers were found in a much larger percentage.

However, it was found that asbestos contamination of these people was not a random occurrence. Both in frequency and degree, such contamination was significantly greater among individuals with any history, however brief, of employment in the construction industry. This biological data, coupled with the knowledge that 2/3 of all asbestos used in the United States is used in the construction industry, has

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served to focus control efforts to this source of widespread community and environmental asbestos contamination.

As a result, specific environmental control programs have been and are being developed. First, since analysis of the detailed uses of asbestos in construction demonstrated that much was "bound in" and not easily airborne, and that that asbestos which was loose, and free to enter the air, was largely used in insulation, an Insulation Industry Hygiene Research Program was established with the active participation of Industry, Labor Scientific groups and the BOSH. Within one year, a number of practical control measures were developed and others are being designed.

Second, the Department of Air Resources of the City of New York has contracted with Mt. Sinai's Environmental Sciences Laboratory to delineate the sources of community asbestos air pollution in NYC; investigation of construction industry practices rapidly identified major emission sources. Combined efforts of the building industry, labor, the asbestos industry, the Department of Air Resources, the Department of Health, and scientists have been initiated to develop those trade practice modifications needed to control these hazards.

Publications: No additional publications.

EC-00163-01 (UI-00972-01)

DEPOSITION AND CLEARANCE OF PARTICLES IN LUNGS

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SALT LAKE CITY, UTAH

Objectives: The objectives of this study are:

1. By intratracheal instillation of papain an emphysematous-like lesion will be developed in one lung of rabbits. Using this animal, and ^{133}Xenon, a comparison of the distribution of ventilation and perfusion in the control and diseased

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hemi-lungs will be made. Also comparison of maximal flow/volume and volume/pressure curves of the two lungs at autopsy will be made.

2. Measure the uptake of ozone by the respiratory systems of animals and humans.

3. Study the physiological effects of low levels (0.1 - 1.0 ppm) of ozone in animals and in humans.

4. To study effects of aerosols on the rabbits having unilateral lung disease.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

EC-00198-08 (UI-00396-08)

POTENTIATION OF TOXICITY IN ORGANIC SOLVENT MIXTURES

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ANN ARBOR, MICHIGAN

Objectives: To investigate the toxicity of halogenated hydrocarbons as potentiated by aliphatic alcohols and polyalcohols. The technique involves the exposure of animals to sequential doses of compounds which, separately, would cause only marginal effects. Toxic manifestations are monitored by determinations of serum enzyme levels and histopathological studies. The group hopes to be able to make structure: activity correlations by examining the effects of equimolar doses of selected compounds.

Studies are described which may permit the chromatographic assay of solvent metabolites in tissues and in incubating homogenates. In vitro studies of the effects of potentiating solvents upon the metabolism of halogenated hydrocarbons are proposed.

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Significant Results: Evidence has been obtained that previous exposure to a variety of alcohols will greatly increase toxicity from a subsequent exposure to carbon tetrachloride.

2. Animal data suggest that, depending upon the dose level, a previous exposure to carbon tetrachloride may at least partially protect an animal from a subsequent exposure.

3. Metabolic studies of carbon tetrachloride show that it is dehalogenated to chloroform and methylene chloride. It appears that toxicity is directly related to the rate of metabolism. These findings in animals probably also relate to man, thus exposures to alcohols of various types and carbon tetrachloride should be avoided. The data on metabolism of carbon tetrachloride which correlates toxicity with rate of metabolism may allow for the development of better methods of treatment now that this relationship is understood.

Publications: No additional publications.

EC-00200-09 (UI-00398-09)

FARMER'S LUNG--AN EXPERIMENTAL INVESTIGATION

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MARSHFIELD, WISCONSIN

Objectives: The purpose of this project is to make a study on the etiology, pathogenesis, and clinical course of the disease called Farmer's Lung. The study falls into three parts:

1. Two agents, thermopolyspora polyspora and thermoactinomyces vulgaris, already have been isolated from human cases and shown to be etiologically related to this disease. Attempts will be made to isolate other thermopilic actinomycetes and to study the histological reaction by electron microscopy and the immune complex in the lung tissue with a fluorescent antibody technique developed in this research.

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in the dairy areas. A more complete recent study confirmed the earlier work and demonstrated the widespread domain of the disease. It was pointed out that the disease must be brought to the physician's attention, particularly in the dairy agricultural areas. Chronic exposure leads to irreversible lung disease, cor pulmonale, and death. Sera from 1,130 farmers were studied, and 13.1% had precipitins to extracts of M. faeni. Healthy farmers did not have precipitins in their sera. Eighteen major clinics and medical institutions cooperated in the study. Those having the highest incidence of sensitization were Pennsylvania, Wisconsin, Illinois, North Dakota, and Manitoba (Canada). The age group 30 to 59 years was most often affected and men outnumbered women 5 to 1. The result on each individual in this study was forwarded to the cooperating institutions.

During the course of the survey, a simplified agar gel diffusion test for Farmer's Lung was developed and was published in the American Journal of Clinical Pathology and has been put into use in many clinical laboratories. More recently, a hemagglutination test for Farmer's Lung antibodies has been developed and was presented at the joint meeting of the Central Society for Clinical Research and the Federation for Clinical Research, November 1969. The antigen is being made available to any laboratory wishing to do the test. This work has also come to the attention of Dr. Ralph Williams, Chief of the Department of Medicine, University of Arizona; and a cooperative immunological project studying the physical characteristics of the antigen-antibody aggregate has been instituted between his group and our own.

To help the microbiologist establish an identification scheme which will also aid in the studies of the disease mechanism in the lung parenchyma, an immunofluorescent test for the organism has been developed. This test can serve as a model for identifying all of the microorganisms found in moldy forage.

An animal study is underway which it is hoped will help further define the pathophysiology of the disease. Data obtained so far indicate that the disease can be produced in guinea pigs. This model will be used to study the immunological response of the lung tissue and develop methods for prevention of that response.

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2. Study of immune process in both men and animals to determine the physical and chemical characteristics of the antigen involved and whether this disease represents delayed hypersensitivity or a modified Arthus reaction.

3. An epidemiological study to determine the role of environmental factors, such as rainfall, on the incidence of the disease in order to develop preventive measures.

Significant Results: Studies have been aimed at establishing methods for the diagnosis, treatment, and prevention. The initial report in 1964 called further attention to the disease and, in particular, the histologic changes in the lung. Interest turned to confirmation of the possible bacterial cause of the disease. However, many microbiologists discouraged the investigations at first because of the great number of organisms found in moldy forage. Nevertheless, it was established that Micropolyspora faeni and Thermoactinomyces vulgaris, two microorganisms found in moldy forage, were directly involved in the disease process. These organisms were isolated from lung biopsy material taken from patients during an acute attack of Farmer's Lung. These studies were subsequently confirmed in other patients.

Further case studies and the initial work on the biochemistry of that part of the organism associated with the patient's immunological response were also reported. Chemical identification of the antigen and a description of its structure is most important before the disease process can be understood. Recent work by our group and others indicates that a number of dusts and organisms produce a group of diseases classified by Pepys as "extrinsic allergic alveolitis," for example, maple bark disease, bagassosis, pigeon breeder's disease, malt worker's lung, and mushroom worker's disease. As a group, these are agriculturally and economically very important.

In an effort to develop information on the prevalence of Farmer's Lung, a study was launched in 1965 to test the serum of farmers with lung disease of unknown cause. This study was carried out throughout the United States and Canada through the cooperation of the American Association of Medical Clinics and the National Institutes of Health. An early report demonstrated a high incidence of sensitization, particularly

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Studies are also underway to develop a method of eradicating the organisms from stored forage. A number of antibiotics inhibit the organism, but further studies must be carried out on the dietary levels of these drugs and their effects on the animals ingesting the feed. These will be done before any mass efforts to eliminate the organism are attempted. Perhaps a better method of eradication is rigid control of the moisture content of the forage. It has been pointed out that at least 30% to 40% moisture is needed for the organisms to grow. This is an important factor, as a direct correlation with the amount of rainfall in the haying season and the number of patients developing the disease has been established.

In summary, this grant has described in detail for the first time the changes in the lung tissue of patients with Farmer's Lung; conducted a survey to point out the importance and extent of the disease in farmers; developed two simplified tests for the disease; described a method for identifying the organisms; developed an animal model to study the disease; alerted physicians and farmers to the potential of the disease; and called these studies to the attention of farmers in a recent issue of Hoard's Dairymen, a national journal. It has responded to consultations from 58 different institutions throughout the United States and Canada and assisted them by testing or establishing diagnostic methods.

Publications: No additional publications.

EC-00201-16
(UI-00399-16)

THE BIOCHEMICAL EFFECTS OF LEAD POISONING

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Objectives: It has been noted that virtually every young child with plumbism (lead poisoning) has an associated iron deficiency anemia. It is proposed to investigate whether a causal association exists by testing (1) whether lead impairs the intestinal absorption of iron, (2) whether a pre-existing iron deficiency alters the distribution of lead within tissues and thereby intensifies the effects of lead, and

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(3) whether with accumulation of unutilized protoporphyrins associated with iron deficiency enhances the absorption of lead from the intestines. These will be studied in weanling rats, which are either iron deficient or iron repleted.

In addition the investigator wishes to study the effect of continued combined chelation therapy during the chronic phase of plumbism in children. It is felt that this approach would cause more efficient deleading and thereby reduce the sequelae of lead intoxication. A total of 45 patients will be studied using: blood lead levels, free erythrocyte protoporphyrin determinations, complete blood counts, urinalysis, urine ALA determinations, EEG, and psychometric evaluation.

Significant Results: During the past year, studies were carried out in 39 children recovering from lead intoxication. All resided in safe housing and most were receiving long-term oral d-penicillamine therapy to facilitate mobilization and excretion of their excessive body lead burden. (It was earlier shown that this chelating agent (d-penicillamine) effectively and promptly reduces blood lead levels to the normal range and suppresses the toxic biochemical manifestations of plumbism.) Whether d-penicillamine accelerates the delivery of the excess body lead burden depends largely on whether it mobilizes lead from bone which is the main repository of lead in the body. In an attempt to answer this question, 32 patients received EDTA and EDTA-PTH (parathyroid hormone) mobilization tests for lead. PTH stimulates osteoclastic activity and, hence, plays an important role in the resorption of bone. Thus, if lead is incorporated deep in cancellous bone in an area inaccessible to chelating agents, the simultaneous administration of PTH (to promote resorption of bone) and EDTA might result in a greater urinary excretion of lead than that which results when EDTA is given alone. The results show that an effective dose of PTH was used, since three- to four-fold increases in urinary calcium excretion were observed; however, no greater urinary lead excretion followed EDTA-PTH than that found following an equivalent dose of EDTA alone in each child. The significance of these results is as follows:

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1. That the lead in bone is accessible to chelating agents for mobilization and excretion and

2. That it is possible to accelerate the excretion of the excessive body lead burden which is an important therapeutic consideration.

It has been thought, in the past, by many that the lead incorporated in bone could not be mobilized by chelating agents.

Since the usual parameters of increased body lead burden (serial blood lead measurements) and lead toxicity (urinary excretion of δ-aminolevulinic acid) are suppressed to the normal range during d-penicillamine therapy, it is necessary to develop new criteria by which to estimate the daily dosage and length of d-penicillamine therapy required in young children recovering from plumbism. Criteria suitable for ambulatory care are desired. All 39 children have received periodic EDTA and d-penicillamine mobilization tests in order to measure the urinary output of lead under these conditions. Various dosage levels of d-penicillamine have been used. The data suggest that d-penicillamine in a dose of 40 mg/kg body weight/day is safe and effective, and that therapy may be terminated when blood lead reaches 20-25 μg Pb/100 G whole blood, as no urinary abnormality remains when this point is reached. This criterion must be considered tentative, however, until adequate control data for the EDTA mobilization test are obtained in young children. These data will be sought during the coming year among younger siblings of the patients known to have been raised in houses free of hazardous environmental lead exposure.

Serial, psychometric, EEG and neurological evaluations for evidence of permanent residual brain damage are being made in all patients. Often, some time must elapse after the initial acute toxic episode of plumbism before the extent of brain damage becomes evident. During the past year, it has become apparent that five of the ten survivors of acute lead encephalopathy in the group have sustained significant permanent brain damage despite vigorous initial and long-term chelation therapy.

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This emphasizes the urgent need for recognition of the child with increased lead absorption prior to the onset of toxic manifestations of plumbism. To this end, work is now in progress aimed at the development and evaluation of techniques which are accurate, sensitive and suitable for the mass screening of young children, particularly those who reside in old high-risk housing.

Publications: Chisolm, J. J. Jr., "Determination of -Aminolevulinic Acid in Plasma," Analytical Biochemistry. 22, 54-56, (1968) Johns Hopkins University and Baltimore City Hospitals, Maryland.

Chisolm, J. J. Jr., "The Use of Chelating Agents in the Treatment of Acute and Chronic Lead Intoxication in Childhood," The Journal of Pediatrics, 73, No. 1, 1-38, (1968).

Chisolm, J. J. Jr., "Treatment of Lead Poisoning," Modern Treatment. 4, No. 4. (July 1967) 710-728. Johns Hopkins University and Baltimore City Hospitals, Maryland.

Chisolm, J. J. Jr. and Kaplan, E., "Lead Poisoning in Childhood - Comprehensive Management and Prevention," The Journal of Pediatrics. 73(6), 942-950. (1968), Baltimore, Maryland.

EC-00202-13
(UI-00400-13)

EVOLUTION OF STRESSES OF EXPOSURE TO HEAT

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Objectives: The purpose of this project is to acquire better quantitative understanding of the factors determining the physiological stresses resulting from exposure to hot environments and physical activity. The information so obtained should be applicable in defining risk factors related to health problems of populations working and living in hot environments. The two major aims of the project are: (a) practical,

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i.e., the influence of clothing as a factor in modifying thermal exchanges; and (b) theoretical, i.e., the interrelationships of local versus general stimuli and response to thermal loads.

Significant Results: Prediction of effects of human exposures to heat is complicated. More than 10 separate climatic and personal factors influence the amount of physiologic strain resulting from exposure to hot climates or to industrial heat sources. Among these are air temperature, wind, humidity, radiation from sun or furnaces, duration of exposure, clothing, body size, level of bodily activity, cardiovascular fitness, and state of acclimatization. We have devised a heat stress index which predicts safe and potentially injurious exposures on the basis of rational consideration of these factors. This index has been widely used; it was a major topic at a recent technical meeting sponsored by the World Health Organization.

Studies have produced data basic to establishing validity of this heat index; for example, on responsiveness and control of the sweating mechanism, on blood flow to the skin, on elevation of body temperature and heart rate and on effects of intermittent exposures to heat and conditions during periods of recovery.

Publications: Hertig, B. A. and Belding, H. S., "Evaluation and Control of Heat Hazards," Temperature-Its Measurement and Control in Science and Industry, 3, Part 3, 347-355, University of Pittsburgh, Pennsylvania.

Hatch, T., "Assessment of Heat Stress," Temperature - Its Measurement and Control in Science and Industry. 3, Part 3, 307-317, University of Pittsburgh, Pennsylvania.

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EC-00203-11 (UI-00402-11)	FACTORS AFFECTING THE EXCRETION OF INDUSTRIAL POISONS	HERVEY B. ELKINS MASSACHUSETTS DEPARTMENT OF LABOR AND INDUSTRIES BOSTON, MASSACHUSETTS

Objectives: The objectives of this project are to: (1) improve reliability and extend the usefulness of urinalysis as a tool for evaluating exposure to, and hazard of, lead, nickel, copper, zinc, trichlorethulene and perchloroethylene; (2) take advantage of unusual exposure incidents by following excretion patterns and to study the effects of therapeutic agents on these; (3) develop and apply small blood sample CO analysis to known CO exposures; (4) determine normal ranges of urinary excretion of elements and metabolites, and (5) compare a coprecipitation method with wet digestion for determining lead in urine.

Significant Results: A study was made of solvent exposure during the painting of the interiors of water standpipes and tanks. The relatively recent introduction of synthetic finishes containing toluene and other volatile solvents, together with improvements in spray painting techniques, have greatly increased the hazards incurred in this process. Several accidents, including deaths due to falls, have resulted during the past few years from painters being overcome by fumes.

Research has developed a method of measuring exposure of workers to toluene by analysis of urine for hippuric acid. As a result the efficiency of the respiratory protective devices worn by painters has been evaluated. It has been shown that cartridge type respirators are inadequate to protect against the concentration of toluene and other solvent vapor frequently encountered in this work.

As a result of study and findings:

1. Procedures have been initiated to change the specifications of the American Water Works Association for water tank construction, to provide more openings so that better ventilation of the tanks during painting can be obtained.

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2. Recommendations for a legal requirement that such tanks in Massachusetts be provided with additional openings have been submitted.

3. Recommendations for precautions to be taken in tank painting and sand blasting, on which it is anticipated that rules and regulations will be based, are being prepared.

Publications: No additional publications.

EC-00205-09
(UI-00404-09)

RESPIRATORY DISEASE AND ENVIRONMENTAL EXPOSURE

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BOSTON, MASSACHUSETTS

Objectives: The purpose of this project is to make a study of the incidence and prevalence of respiratory disease in populations exposed to different quantities and types of air pollutants.

The major population involved is a random sample plus selected occupational samples in Berlin, New Hampshire, with comparable community-based studies being conducted by others in Canada and England. To date, a major observation appears to be that smoking habits are much more important than ambient pollutants in causing respiratory disease. However, some trends have appeared in specific populations suggesting effects from ambient pollutants, usually job related. The studies involve questionnaires re-exposures, illness history, etc., tests of forced vital capacity and similar respirometry, and monitoring of pollutants in specific environment. Also, absence records for school children are being obtained. There has been cross-validation with the other two studies, and this will continue.

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Significant Results: Analyses of data for the resurvey of Berlin, New Hampshire, has indicated that the disease prevalences in 1967 are slightly less than they were in 1961. Levels of air pollution have remained at approximately the same level for both SO_2 and particulates. Data were standardized for age, sex and cigarette smoking habits. This difference may be related to the increased use of filter-tip cigarettes, but this has not been checked as yet.

A reexamination of the results obtained on those persons during the 1961 survey who have died indicates that the simple tests of pulmonary function /Forced Vital Capacity and Forced Expiratory Volume (1 sec.)/ were lower than in those who were still alive. This substantiates data that the simple tests can have good prediction value.

Normal values have been developed for the single-breath diffusing capacity and the total respiratory resistance by the method of forced oscillations. Both of these tests have use in surveys of population groups, and normal values from general populations are necessary.

A further analysis of the diffusing capacity has permitted a separation of this into two components - a membrane component and the volume of blood in the capillaries. The membrane component decreases with age - that is the diffusing capacity is impaired. The volume of blood in the capillaries also decreases slightly with age but it decreases much more markedly with cigarette smoking. It is the change in this component that acounts for the decreased diffusing capacity observed in cigarette smokers. This may be a reversible phenomenon since persons who have given up smoking have been reported as showing an improvement in their diffusing capacity. This needs more verification.

Analysis of a survey in a local shipyard has shown that the men who handle asbestos (pipe coverers) have more respiratory disease as measured by x-ray change in the lungs and by tests of pulmonary function as compared with two other groups - welders

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and pipe fitters who have much less exposure. The exposures of the pipe coverers to asbestos have shown some brief relatively high exposures but the general average has probably been close to the so-called threshold limit values.

These results tend to confirm earlier study and indicate that the current allowable levels for asbestos exposures should be reduced.

Publications: Peters, J. M., Murphy, R. L. H., Pagnotto, L. D. and Van Granse, W. F., "Acute Respiratory Effects in Workers Exposed to Low Levels of Toluene Diisocyante (TDI)," Archives of Environmental Health. 16, 642-647, (May 1968), Harvard University, Boston, Massachusetts.

EC-00206-08 (UI-00406-08)

LEAD CHELATION IN RATS

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MINNEAPOLIS, MINNESOTA

Objectives: The basic aims of this proposal are: 1) Characterization of the relation of the total skeletal burden of lead to the EDTA-sensitive skeletal fraction and to the soft tissue burden, 2) characterization and determination of the functional significance of the carrier system for lead, 3) characterization of the mechanisms of action of other chelating agents regarding mobilization of lead and 4) comparison of the chelation of plutonium to lead. The first aim will involve determination of the decrease in body burden with time, and partition of lead between the soft tissue, EDTA-sensitive skeletal pool, and the EDTA-insensitive pool immediately after EDTA and after reequilibration of the total body burden. The second aim will be studied by chromatographic isolation of the lead-carrier protein in tissues and plasma. The interaction of this complex with EDTA and bone will be determined. Aim 3 will

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involve comparison to EDTA of two or three other chelators known to be more effective, with particular attention to the question of whether their superiority is due to a more intense effect on the skeletal pool of lead or due to an action on soft tissue lead. Aim 4 will compare the chelation of plutonium to that of lead, particularly with regard to mechanism. Also an attempt will be made to define the anatomical site of lead mobilization in bone by EDTA, utilizing the techniques of micro-radiography and autoradiography applied to thin sections of bone.

Significant Results: The single most important finding resulting from investigations has been that the major source of lead mobilized and excreted under the influence of these drugs is the bone. Results are at variance with those of two European investigators -- Castellino in Naples and Teisinger in Prague. The magnitude of lead mobilization found involving bone is so great and the evidence for its nature so convincing that it is impossible to believe the European work. It actually exceeds the total soft tissue pool of lead. A major consequence, for which there is unpublished evidence, is that the mobilization of lead from bone is accompanied by actual elevations of the concentrations of lead in soft tissues. The more effective the therapeutic regimen (in terms of total lead excretion), the less the net mobilization from the soft tissue pool. It has been found that, contrary to accepted dogma, parathyroid extract does not enhance the excretion of lead. At least this is so in the rat. The only other studies that are known on this point are those of Hunter and Aub in man, dating back to 1927. These workers claimed that PTE enhanced lead excretion in their patients, and this has been accepted as fact ever since. Their data, however, are not at all convincing.

The practical significance of the findings is largely in regard to chelation therapy. EDTA and DTPA are used very extensively for therapy and sometimes to assess the body burden of lead in people subjected to industrial exposure. The findings reported here contribute to the understanding of the hazards of therapy associated with translocation of lead to soft tissues. Indeed, pediatricians have

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reported temporary deterioration of children treated with EDTA. This has been accompanied by further increase in the inhibition of heme synthesis already in evidence in the poisoned child, as well as accentuation of aminoaciduria. Information being obtained concerning the metabolism of lead in bone contributes to the pool of information badly needed today in the interpretation of blood data being gathered in the general population, being exposed to variable amounts of lead.

Publications: No additional publications.

EC-00207-11
(UI-00408-11)

THE DUST LAYER AND PRECIPITATOR EFFICIENCY

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Objectives: The aim of this project is to make a study of the effect of the behavior of the dust layer on electrical precipitator efficiency. In particular, dust adhesion and sparkover originating at the dust layer will be studied. The purpose of studying dust adhesion is to determine the conditions conducive to the formation of large chunks which can fall into the collecting hopper with a minimum of re-entrainment. In the study of sparkover, the purpose is to determine the characteristics of the dust layer which initiate discharge pulses that can develop into sparks. Spark discharges reduce operating voltage thereby lowering precipitator efficiency.

Significant Results: The effect of particle size on precipitator efficiency has been investigated. The purpose of this work is to reduce the confusion regarding the application of the Deutsch equation. This equation has been widely used to calculate precipitator efficiency. The equation was derived by assuming a known operating voltage and idealized conditions which do not exist in precipitators. In use, it requires a different constant for each application and condition. It has been useful

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to a few very experienced designers with a wealth of test data from which to select the best constant, but the equation has only served to confuse most engineers. This analysis of the effects of mixtures of particle sizes serves to give engineers an understanding of the cause of some of the confusing behavior of precipitators.

Work is in progress studying the degree of turbulence that exists in laboratory precipitators. This will aid in evaluating another assumption of the Deutsch equation.

The work on adhesion is a long program which is gradually accumulating information on types of adhesion and the basic mechanisms involved. Currently the contribution of contact potential differences is being evaluated.

The effect of circuit parameters, especially capacitance, on sparkover voltage is being studied. For the type of sparkover occurring in precipitators, sparkover voltage increases as circuit capacitance decreases. This serves to explain some of the decrease in operating voltage as the size of a precipitator increases and will aid in predicting performance of a full scale precipitator from test of a pilot sized unit.

Publications: Acker, F. E. and Penney, G., "Influence of Previous Positive Streamers on Streamer Propagation and Breakdown in a Positive Point-to Plant Gap," Journal of Applied Physics, 39(5), 2363-2369. (1968), Carnegie Mellon University, Pittsburgh, Pennsylvania.

Penney, G., "Weaknesses in the Conventional Theory of Electrostatic Precipitation," ASME Publication 67-WA/APC-1, 7 pp, Carnegie Institute of Technology. Pittsburgh, Pennsylvania.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00208-07 (UI-00411-07)	OCCUPATIONAL HEALTH HAZARDS OF RUBBER DUST	CARL A. NAU UNIVERSITY OF OKLAHOMA MEDICAL CENTER OKLAHOMA CITY, OKLAHOMA

Objectives: In the initial phases of the inhalation work, considerable difficulty was encountered in preparing and redispersing an appropriate dust from automobile tires. The methodology has now been successfully established and inhalation work on monkeys, mice and hamsters is under way. The animals are exposed for 6 hours a day for 5 days a week to 0.5 mg of rubber dust with 1.5 mg carbon black per cu. ft. The monkeys are periodically examined by chest X-ray. It is proposed to expand the number of monkeys. Some will be sacrificed at intervals and with others exposures would be continued 10 years. A detailed study of the larynx of exposed hamsters is being made in cooperation with the Department of Otolaryngology. We are told that this will add much interest and valuable information and that it will be extended to primates. Presumably the findings are too preliminary for discussion at this time. A pilot feeding study in which C_3H mice were fed a diet containing 10 percent rubber dust in Rockland Chow has indicated a reduction of life span as well as a depression of growth in spite of an increased food consumption. They propose to expand the feeding studies using rats on paired feeding. They also propose a balance study to determine if there is a difference in composition of the rubber dust in the diet and in the feces. Animals will be sacrificed and the tissues will be analyzed for various components of the rubber.

Significant Results: The total number of hours of exposure thus far is approximately 8,000. All animals are kept under close observation and a chest X-ray of each animal is made every 6 months. The results of these examinations, as well as gross microscopic examination of lung tissue, shows a slow rate of accumulation in the primates. Hamsters

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were also exposed to this same concentration of rubber dust. A very slow rate of accumulation of rubber particulates in the hamster lungs was observed. This suggests that the lung clearance capability of the hamster is exceedingly good.

The effect of rubber dust and its chief component - carbon black - on plant and animal cells, in vitro, was also studied. In general the results indicate that rubber dust as well as carbon black made either by the furnace or thermal process in increasing concentrations in the substrates, result in an increasing inhibition of the growth of Hela cells (human carcinoma of the cervix) Wi-38 cells (human fetal diploid cells derived from the lungs) and tobacco callus tissue (nicotina tobacum, variety Wisconsin 38). Other observations suggest that these dusts significantly alter the free proline content of these cells. The significances of this is being studied.

Pulmonary function tests have been started on monkeys to determine if there is any detectable impairment of function in primates exposed to rubber dust. Thus far, technical difficulties have caused delay in getting significant data. These difficulties arise out of the small volume of air the monkey inhales and exhales with each breath and the difficulty in making repeated "arterial sticks" for the procurement of arterial blood (without damage to the test animal).

Rubber dust has been analyzed qualitatively and quantitatively for 3,4 benzpyrene, a known carcinogen. A reliable and reproducible test has been developed. Rats are now being fed the analyzed rubber incorporated into rat food and urine and feces of these rats are being collected for analysis for the known carcinogen 3,4 benzpyrene (or its metabolites).

It has been determined that particulate rubber is an air pollutant and that it can be accurately quantitated in the air. It is hoped that our studies will give us information as to impairments, if any, which may result from the inhalation or ingestion of rubber dust, and standards of concentration of rubber dust in air which may be determined to be potentially hazardous.

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EC-00208-07 (Continued)	Publications: No additional publications.	
EC-00209-07 (UI-00412-07)	EFFECTS OF CCl_4 ON ISOLATED, PERFUSED RAT LIVER	MURRAY HEIMBERG VANDERBILT UNIVERSITY NASHVILLE, TENNESSEE

Objectives: It is proposed to continue the investigation of the action of CCl_4 on hepatic lipid metabolism. From work with the isolated, perfused rat liver, it is clear that the inhibition of outward transport of hepatic triglycerides is a major metabolic lesion responsible for the development of the CCl_4 fatty liver. It would appear then that CCl_4 may be profitably employed as a metabolic poison to study basic mechanisms of hepatic lipid transport. During the past few years much has been learned about lipoprotein synthesis and the release of triglyceride, phospholipid, and cholesterol into the serum as a result of the study of hepatotoxicity induced by CCl_4. It is desired to expand this study to include various hormones, drugs, and toxic agents in addition to CCl_4 which may produce a fatty liver and mobilize free fatty acids, or which may inhibit free fatty acid mobilization and reduce blood lipids *in vivo*. Of interest in this regard are:

1) The hormones, insulin and glucagon
2) Drugs such as nicotinic acid, triparanol, atromid, and others which have the dubious virtue of decreasing blood cholesterol and,
3) Certain drugs which at high concentration may be hepatotoxins, such as halogenated hydrocarbons, phenothiazines and tetracyclines.

It is hoped that success is met in obtaining useful information of mechanisms and regulatory processes of hepatic lipid metabolism and transport, and that later this information may be applied to the development of rational approaches to therapy of disorders of lipid metabolism in man.

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EC-00209-07
(Continued)

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: Van Harken, D. R., Dixon, C. W. and Heimberg, M., "Hepatic Lipid Metabolism in Experimental Diabetes: V. The Effect of Concentration of Oleate on Metabolism of Triglycerides and on Ketogenesis," Manuscript, 35 pp, Vanderbilt University, Tennessee.

Heimberg, M. and Wilcox, H. G., "The Isolation of Serum Lipoproteins by Zonal Ultracentrifugation. I. Evaluation and Experimental Procedure," Manuscript, 39 pp, Vanderbilt University, Tennessee.

Heimberg, M. and Wilcox, H. G., "The Isolation of Serum Lipoproteins by Zonal Ultracentrifugation. II. A Comparison of Serum Lipoproteins from Various Animal Species," Manuscript. 25 pp, Vanderbilt University, Tennessee.

Dingell, J. V. and Heimberg, M., "The Effects of Aliphatic Halogenated Hydrocarbons on Hepatic Drug Metabolism," Biochemical Pharmacology, 17, 1269-1278, Printed in Great Britain.

Wilcox, H. G. and Heimberg, M., "Isolation of Human Serum Lipoproteins (LP) by Zonal Ultracentrifugation (ZU)," Federation Proceedings, 26, No. 2, (March-April 1967).

Weinstein, I., Willhite, L., Klausner, H. and Heimberg, M., "Induction of Fatty Liver *in Vitro* by CCl_4," The Pharmacologist, 9, No. 2, (Fall 1967).

Heimberg, M., Wilcox, H. and Van Harken, D. R., "Hepatic Triglyceride Metabolism in Experimental Diabetes," Progress in Biochemical Pharmacology, 3, 353-367, (1967).

Van Harken, D., Dixon, C., and Heimberg, M., "Hepatic Lipid Metabolism *in Vitro* During Maintenance of Steady State Concentrations of Perfusate Oleic Acid," Federation Proceedings, 26, No. 2, (March-April 1967).

Van Harken, D., Brown, T. and Heimberg, M., "Hepatic Lipid Metabolism in Experimental Diabetes. III. Synthesis and Utilization of Triglycerides," Lipids. 2, No. 3, 231-238, (May 1967).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00209-07 (Continued)

Heimberg, M., Van Harken, D. and Brown, T. O., "Hepatic Lipid Metabolism in Experimental Diabetes. II. Incorporation of (I-14C) Palmitate into Lipids of the Liver and of the d<I.020 Perfusate Lipoproteins, Biochem. Biophys. Acta. 137, 435-445, (1967).

Klausner, H. and Heimberg, M., "Effect of Adrenalcortical Hormones on Release of Triglycerides and Glucose by Liver," American J. of Physiology, 212, No. 6. (1967).

Heimberg, M., "Lipids and Lipoproteins of Human Serum," The Journal of the Tennessee Medical Association, 61, No. 2, 167, (1968).

Weinstein, I., Willhite, L., Klausner, H. and Heimberg, M., "The Requirement of Free Fatty Acids for the Fatty Liver of CCl_4 Intoxication," Proceedings of the Society for Experimental Biology and Medicine, 127, 850-854 (1968).

Wilcox, H. G. and Heimberg, M., "Preparative Isolation of Plasma Lipoproteins (LP) by Zonal Ultracentrifugation (ZU)," Federation Proceedings, 27, No. 2, (March-April 1968).

Wilcox, H., Dishmon, G. and Heimberg, M., "Hepatic Lipid Metabolism in Experimental Diabetes. IV. Incorporation of Amino Acid 14_C into Lipoprotein--Protein and Triglyceride," J. of Biological Chemistry, 243, No. 3, 665-675 (1968).

EC-00210-07
(UI-00414-07)

PARTICLE DYNAMICS IN INERTIAL FIELDS

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Objectives: In this project theoretical and experimental studies will be made of the drag forces on particles in high inertial fields under such conditions that the fluid acceleration and magnus force terms would be important. The past work indicates that, under the high accelerations experiences in strong inertial fields, these terms are important, although usually neglected in quasi-steady state solutions. It is proposed to study these effects both theoretically and experimentally. It is also proposed to continue the study of the ballistic trajectories of small particles The major emphasis will be on complex fluid particle interactions and on transient effects.

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EC-00210-07
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Significant Results: Significant progress has been made during the past year in developing a centrifugal separator for classifying particulate matter having diameters extending well into the sub-micron range. The techniques necessary for reduced pressure operation have been perfected to the point that consistent classifications of sub-micron aerosol particles are now possible. Also, the capacity of the classifier has been increased by a factor of 1000 and flow rates of several liters per minute are possible.

Work has continued on determining the effects of transient drag forces on particle trajectories. Mathematical models have been formulated and partial solutions obtained. Most of the better results to date have been obtained without consideration of the so-called "integral" drag term. Numerical solutions are presently being sought that include the "integral term."

An elutriation-based particle classifier has been developed that utilizes diverging flow conduits and graduated sieve trays. This device appears to hold promise for large-scale separations of subsieve particles.

Particle trajectory studies in liquids and across the interfaces between immiscible layers is presently being investigated as a promising new technique for size classification.

Publications: No additional publications.

EC-00211-06
(UI-00416-06)

ENVIRONMENTAL FACTORS IN OCCUPATIONAL DERMATITIS

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Objectives: The objective of this project is to make a study investigating environmental factors which may be important in occupational dermatitis. During the past

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EC-00211-06
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three years study has been made of the effects of hydration, humidity, and temperature on the reaction of the skin of guinea pigs to such agents as edible oils, straight chain aliphatic alcohols, acids and to methyl nicotinate. In brief, that already known has been confirmed; namely, that increased hydration, higher temperatures, and higher relative humidity all enhance absorption through the skin. If the substance penetrating is an irritant then irritation will occur if conditions which favor penetration are present. It is now desired to repeat the same studies using human skin and studying particularly the forearms. Study will be made of the penetration of C^{14} labeled substances in both guinea pigs and humans both in vivo and in vitro. Finally, brief mention is made that a search for physicochemical models which might simulate plasma membranes of normal epidermal cells will be undertaken.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

EC-00212-06
(UI-00419-06)

LUNG MECHANICS AND SURFACE PHENOMENA

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Objectives: This investigation is concerned with relating surface phenomena to the mechanical behavior of the lungs, including distribution of ventilation. Further plans for research include: defining the origin and properties of surfactant employing electron microscopy and histochemistry; studies of effects of chemical, gas mixtures and other procedures, etc.

Significant Results: The effects of toxic levels of oxidants on living organisms are being studied. For example, rabbits and mice usually die within three to four

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days from continuous exposure to 100% oxygen (at ambient pressure) and the lungs show extensive damage. At the cellular level, recent work suggests that long before structural changes are seen, DNA synthesis in lung alveolar cells is greatly decreased by this high oxygen exposure. It is believed that these studies serve as a useful model for predicting that similar effects might result from exposure to other oxidants such as ozone or oxides of nitrogen. It is hoped that work will ultimately furnish a new basis for judging limits of "safe" oxygen concentration in man.

The lungs are the meeting place of fresh air and blood. Even slight alterations in normal function produce mismatching of the air and blood within the lungs. The measurement of nitrogen dissolved in body fluids is a sensitive index for assessing this dysfunction. Recent innovations in the methods of measurement (developed as part of this project) suggest that this index of dysfunction can be more widely implemented in human and animal studies. If this proves true, it will provide another important tool in screening for early bronchitis and emphysema, as well as being an invaluable aid to detect early effects of irritant air pollutants.

Publications: Hackney, J. D., Bils, R. F., Takahashi, Y., Rounds, D. and Collier, C., "Organotypic Culture of Mammalian Lung-Studies of Morphology, Ultrastructure and Surfactant," Current Research in Chronic Airways Obstruction, PHS Publ. 1717, 13-34, (May 1968), Ninth Aspen Emphysema Conference.

Hackney, J. D., Bils, R. F., Evans, M. J. and Rounds, D. E., "Functional and Morphological Response of *in vitro* Lung and Myocardian Test Objects to Experimental Gas Environments," APCA Journal, 18(1), 9-11, (1968).

Mark, G. E., Hackney, J. D. and Strasser, F. F., "Morphology and Contractile Behavior of Cultured Heart Cells, and Their Response to Various Oxygen Concentrations," Factors Influencing Myocardial Contractility, 301-315, (1967).

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EC-00213-06 (U1-00421-06)	MANGANESE POISONING--A METABOLIC DISORDER	GERALD P. HANSON PAN AMERICAN HEALTH ORGANIZATION WASHINGTON, D. C.

Objectives: This project concerns the studies of manganese metabolism in Parkinsonian patients at Brookhaven and in manganese miners in Chile. The study will be extended to patients with various collagen diseases, some of whom have defective radio-manganese storage and excretion mechanisms. The same is true of a genetic strain of ataxic mice (known as Pallid mice), which will also be the subject of further investigation under this project. Plans for the future involve not only further studies on the pathogenesis of these disorders, but also various therapeutic trials. Thus dopa will be administered to patients with manganese poisoning in the hopes of inducing symptomatic improvement. Corticosteroids, which have been shown to promote the biliary excretion of manganese in mice, may also be tested in poisoned miners. The complex interrelationships between manganese and iron metabolism will be subjected to further study. Apparently these two elements compete for a common intestinal absorption mechanism, but otherwise the two metals are metabolized in quite separate and distinct ways. It has been suggested that the homeostatic control of manganese is largely based on excretory mechanisms, while that of iron is known to be accomplished by the regulation of intestinal absorption. Current studies on the inhalation of aerosolized $^{54}MnCl$ in miners and normal controls will be continued. If appropriate equipment is provided, the lungs, livers and abdomens of these patients will be scanned for the distribution of radiomanganese. In this way the sites of intestinal absorption are expected to be revealed, and the uniformity or nonuniformity of the pulmonary distribution may be established.

In the meantime, at Brookhaven, animal studies of manganese metabolism will be continued, as well as clinical studies on patients with Parkinson's Disease. Considerable effort will be expended to develop "nondestructive" methods of neutron activation analysis on tissue specimens. If successful, these methods will allow

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multiple determinations of trace metals in tissue specimens, while preserving them so that they can still be subjected to other chemical analyses and perhaps to histological examination.

Significant Results: This international project has permitted long standing collaboration between the Chilean scientists working with Ismael Mena and the U.S. scientists working with George C. Cotzias. Basic research was done as well as translated into prevention and therapy of some neurological diseases.

The original assumption was that chronic manganese poisoning, a crippling disease of the brain, is a metabolic disorder and not strictly a poisoning. Based largely on physiological work and on analytical techniques it was proved that excesses of metabolically active manganese exist in the tissues of normal, healthy manganese miners. Crippled ex-miners had cleared this excess without clearing the symptoms of their disease. Episodic flooding of their brains with gross excesses of metal seemed to have killed some parts of their brains. This flooding was made possible by factors including nutritional deficits which increase absorption of iron.

This latter discovery was relevant to the prevention but not to the cure of this disease since revival of dead brain cannot be induced. It was postulated however that the brain cells that had died may have been "feeding" some surviving cells which were now deficient and therefore responsible for the symptoms. If this were true, correction of their deficiency would correct the disease.

Some symptoms of manganism are found also in Parkinsonism. At Brookhaven, Parkinsonism was treated successfully with L-Dopa, a precursor for the synthesis of substances missing in the Parkinsonian brain. If the symptoms which are shared by both diseases are due to chemical changes in living cells and not to cellular death, L-Dopa should improve the symptoms of manganism also. This important, hopeful hypothesis received strong support by the remarkable, sustained improvement of 7 out of 8 cripped ex-miners

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treated with L-Dopa. The eighth was made much worse by L-Dopa, but, in our animals 5-OH tryptophane (HTP) had generally displayed opposite effects from those of L-Dopa. HTP produces serotonin, Dopa produces dopamine in the brain. On that basis this 8th miner was improved by HTP and a precedent was established to be tested in other diseases, most of the symptoms of which may be aggravated by L-Dopa. If some symptoms are made better and others worse in the same person, one cannot give both L-Dopa and HTP because they compete with each other on their way to the brain. One needs, therefore, substances of similar nature which use different paths to enter the brain. A Dopa-like substance which obeys this specification was found to be Apomorphine. This short-lived substance can be used to prove the reversibility of neurological symptoms in the presence of HTP. It constitutes a model for the synthesis of a new generation of drugs for diseases such as these.

This work has brought a Lasker Award to one of the grantees as well as high editorial and congressional praise to all.

Publications: Sergio, F. P. and Ismael, M. G., "Chronic Manganese Poisoning and Its Relation to the Diseases of the Extrapyramidal System," Intoxication from Manganese, Foreign document (English summary), 667-674, Universidad Catolica de Chile.

EC-00214-06
(UI-00422-06)

DEATH RATES IN ITALIAN RAILROAD EMPLOYEES

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CENTRO PER LE MALATTIE
CARDIOVAS DI ROMA
ROME, ITALY

Objectives:

1. To establish an age-specific cohort mortality table, by cause of death, of the entire employee population of the Italian railroad system.

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EC-00214-06 (Continued)

2. To establish age-specific cohort mortality tables by cause of death and by occupation groups classified according to level of physical activity, job responsibility, and socio-economic class.

3. To construct a table, by age and occupation groups, of mobility between occupation groups within the railroad system.

4. To develop a withdrawal (termination of employment with the railroad) table by age and occupation so as to measure the stability of the cohort.

Significant Results: The objectives listed above had to be reached by evaluating data of the quinquennium April 1, 1963, to March 31, 1968, on a population of about 172,000 persons at entry.

During 1969 the research group completed the collection of data related to the last "events" of 1968 and coded all the data. Recently they have been also transferred to punch cards for computer analysis. A general program for the analysis has been established and agreed with the consultant Dr. Henry Taylor of the University of Minnesota, Minneapolis, Minnesota. It was hoped to produce, by the end of 1969, several basic tabulations on the main items, but this became impossible owing to the long job of coding (mainly because of the complexity of the medical codes) and the need of several and careful controls and checks of the codes themselves. The actual analysis shall be developed and completed only during 1970. The first rough tabulations of the whole analysis have been made.

Only few preliminary words can be said on this material. Apart from the exponential increasing of mortality with increasing age (which is too known) it can be outlined that the general mortality seems to be higher in occupation groups with high physical activity as compared to those with lesser physical activity at work.

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EC-00214-06 (Continued)

No conclusions can actually be drawn because the main interest is focused on the study of mortality from coronary heart disease, which has not yet been analyzed.

Publications: No additional publications.

EC-00215-05 (UI-00423-05)

BIOLOGICAL EFFECTS OF CHROMIUM AND FERROCHROME ALLOYS

KLAUS L. STEMMER
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CINCINNATI, OHIO

Objectives: The purpose of the investigation is to establish the absorption, intracellular transport and deposition of trivalent chromium, beryllium, and cadmium. A special focus is on the tracheal and bronchial mucosa and the alveolar tissue. The interactions between subcellular components and the metals will be compared. The differences will be related, if possible, to morphologic alterations as manifested by light and electron microscopy. Additionally, the inhibition of the function of these subcellular components after interaction with the metals will be studied.

Significant Results: 1. The absorption studies showed that the lung is one of the few organs to absorb metals in the ionic form. Neither *in vivo* nor *in vitro* significant amounts were absorbed by the intestine, liver, kidney, or spleen when these tissues were exposed to chromium chloride.

2. The lung seems to be the organ of storage for chromium which, if proven in the on-going experiments, would be of major significance for the physiological significance of this metal as well as in exposures from the environment or industry.

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3. A new methodology has been developed by which the different cell types occurring in the lung can be separated. This enables the investigator to study each individual cell type in its response to toxic materials. It yields the possibility also to investigate the normal biological functions of these cells, an area which is markedly underdeveloped in regard to lung tissue.

Publications: No additional publications.

EC-00216-06 (UI-00424-06)

BIOCHEMICAL AND PHYSIOLOGIC RESPONSE TO TOXIC STRESS

SHELDON D. MURPHY
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BOSTON, MASSACHUSETTS

Objectives: The aims of this proposal are:

1. To obtain additional information on how toxic agents may interfere with adaptive mechanisms to other environmental stresses.

2. To investigate to what extent unusual responses to chemicals may be controlled by adaptations in metabolic regulatory mechanisms initiated by other stress factors.

3. To determine what biologic pathways lead to altered liver enzyme activities.

Rats and guinea pigs will be employed using treatment with acrolein, organophosphate insecticides, carbon tetrachloride, and allylalcohol. The parameters to be measured include plasma and urinary corticosteroids, liver tyrosine transaminase, liver alkaline phosphatase, and liver microsomal enzymes.

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EC-00216-06 (Continued)

Significant Results: Administration of carbon tetrachloride or thioacetamide to rats partially prevented the increase in tyrosine-α-ketoglutarate transaminase activity in liver that normally occurs after cold stress or administration of cortical hormones. The time after administration of these hepatotoxic chemicals at which reduced enzyme induction occurred was different. However, the results indicate that liver acutely injured by certain chemicals has reduced capacity for metabolic adaptation to environmental stress.

Another area of research was concerned with the relative sensitivities of two enzymatic criteria of liver injury as predictors of a decrement in animals' capacity to detoxify a barbiturate. Plasma glutamic-pyruvic transaminase (an enzyme used in the clinical evaluation of liver injury), liver glucose-6-phosphatase (an enzyme associated with the endoplasmic reticulum of liver cells) and duration of sleeping time after a standard dose of hexobarbital were measured in rats given varying doses of carbon tetrachloride, thioacetamide and allyl alcohol. Carbon tetrachloride and thioacetamide decreased liver glucose-6-phosphatase activity and prolonged hexobarbital sleeping time at doses below those which increased plasma glutamic-pyruvic transaminase activity. This indicates that clinical measurements of this plasma enzyme may not detect minimal levels of liver injury that are sufficient to reduce the metabolism of drugs and foreign chemicals. Increased plasma transaminase activity was the most sensitive indicator of an effect of allyl alcohol, however. This suggests a mechanism of hepatotoxicity for this compound that differs from that of carbon tetrachloride and thioacetamide.

Interactions between the natural circadian variation of adrenocortical activity and stimulation of the pituitary-adrenal cortex by toxic chemicals in rats was studied. The elevation of plasma and adrenal corticosterone levels after a single dose of acrolein (an irritant) or parathion (an insecticide) were greatest when the chemicals were given shortly before the natural circadian rise in corticosterone concentration.

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EC-00216-06 (Continued)

Studies of the effect of feeding insecticides (DDT and parathion) for two weeks showed that the time and amplitudes of the circadian adrenocortical rhythm was not altered by dietary concentrations that were several times greater than current residue tolerance limits for these insecticides.

Publications: No additional publications.

EC-00217-05 (UI-00431-05)

BUTADIENYL PLUMBANES--DIELS ALDER AND OTHER REACTIONS

ERIC C. JUENGE
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PITTSBURG, KANSAS

Objectives: The synthesis of examples of all structurally isomeric butadienyl (conjugated and nonconjugated) plumbanes and determination of their stereoisomerism (geometric and optical) will be completed. In particular, the chemistry of vinylacetylene will be investigated. The 1.4 versus 1.2 addition of trialkyllead hydride or trialkyllead lithium will be investigated. Combinations of the mode of addition, 1.4 or 1.2, and mechanism of addition; ionic or free radical, will determine the stereochemical butadienyl isomers obtained. Rearrangements occurring in these preparations and in the reaction products will be interpreted. These new butadienyl lead compounds as well as known vinyllead compounds will serve as dienes or dienophiles in typical Diels-Alder reactions. Generally compounds of the type $R_xPbR'_{4-x}$ (x = 1-4) where R is a butadienyl or vinyl group and R' is an alkyl or aryl group will be used as dienes or dienophiles.

New compounds prepared in this work may be useful in associated health programs involving radiation shielding polymers, cancer chemotherapy, lead toxicity and detoxification studies. In connection with this research, polymerization and copolymerization work, synthesis of complex organic compounds should yield fundamental information on radiation shielding, cancer chemotherapy, and lead detoxification, respectively.

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EC-00217-05 (Continued)

Significant Results: A clear colorless transparent radiation shielding polymer has been prepared. This polymer is expected to show gamma and neutron shielding properties because of its shielding properties and overt practical applications (shielding windows, flexible shielding building materials, greenhouse windows--transparent to permit plant growth--rolls of sheet for protection against fallout, fibers to make radiation suits, etc.) remain to be investigated. The required monomer, plumba(4.4)nonane, developed in this laboratory, represents a new type of compound, a plumbaspirane, which we have polymerized by free radical initiation, thermally or by cold storage polymerization. The cold storage process involves a slow polymerization of the pure polymer at low temperatures to produce a clear glassy polymer.

A wide variety of butadienylplumbanes (both types, 1- and 2-butadienylplumbanes) have been successfully prepared. The essential function of the butadienyl group for the preparation of natural and synthetic rubbers and polymers is well known. Thus, unsaturated and cyclic plumbanes (including vinylplumbanes and plumbacyclopentances prepared in our laboratories) are now available for polymerization. It is now possible to investigate the polymerization of these varied monomers, affording polymers with custom-made properties. These monomers will produce polymers with lead attached to, as well as incorporated in, the backbone. New compounds prepared in this work may be useful in associated health programs, involving radiation shielding polymers, lead toxicity and lead detoxification studies. Cleavage studies offering information on detoxification of organolead compounds through conversion to non-fat soluble salts have been done on practically all compounds prepared. The butadienyl function of the plumbane should permit incorporation of lead into complex condensed systems, (e.g., steroids by way of the Diels Alder Reaction) and polyclic systems.

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EC-00217-05
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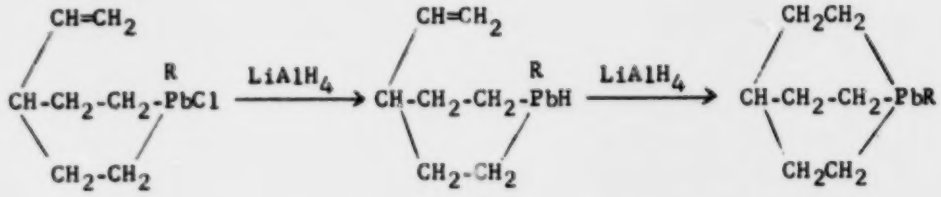

Incorporation of lead into carcinogenic structures may yield cancer chemotherapeutic agents. Investigations of this application, as well as polymerization, have not previously been possible because the butadienylplumbanes were not available. Since simple organolead compounds have shown some activity against leukemia, novel organolead compounds prepared have been submitted for cancer therapeutic testing. Clinical evaluation is incomplete.

Two new techniques have been discovered for the preparation of unsaturated organolead compounds, the reaction of trisubstituted lead (tin) lithium with 1-chloro-1,3-butadiene and the *in situ* hydride addition by reaction of trialkylmetal halide, lithium aluminium hydride, and unsaturated hydrocarbons.

For the practical production of larger amounts intricate organolead polymers, a more convenient technique may be needed. This is another important application of "internal" *in situ* hydride addition. Through this technique polymerization of simple monomeric materials such as unsaturated trialkyllead halides and unsaturated dialkyllead dihalides

$$CH_2{=}CHPbR_2Cl \xrightarrow{LiAlH_4} CH_2{=}CHPbR_2H \longrightarrow \{CH_2CH_2PbR_2\}_x$$

$$CH_2{=}CH{-}CH{=}CHPbR_2Cl \xrightarrow{LiAlH_4} CH_2{=}CH{-}CH{=}CHPbR_2H \longrightarrow \{CH_2{-}CH{=}CHCHPbR_2\}_x$$

is possible (vinyllead halides are readily available in high yields).

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EC-00217-05 (Continued)	Publications: No additional publications.	
EC-00218-03 (UI-00432-03)	A STUDY OF ASBESTOS EXPOSURES AND EFFECTS ON MAN	IRVING R. TABERSHAW UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

Objectives: Observations are being made on the work exposures and on the mortality experience of a group of building trades workers exposed to asbestos in the course of their employment, and comparisons made with other construction workers with minimal exposures to asbestos. Men currently employed in the industry are being studied for X-ray evidence of asbestosis, to determine the prevalence in the present working population and to provide a base-line for future observations on the incidence of lung and pleural tumors.

The proposal now is to pay the technician formerly associated with the San Francisco General Hospital studies to examine sputa from the insulation workers. Sputum specimens are to be obtained on new employees (about 24 per year) before exposure and every month thereafter. In addition, sputa would be collected every 6 months from 275 employees with more than 10 years of exposure to asbestos.

Significant Results: During the fiscal year 1969, followup observation of insulating workers in Northern California was continued. Lung cancer deaths during the period 1946 to 1965 in men with over 20 years since joining the trade were 7.9 times expected; 41% of the workers with this amount of experience showed X-ray evidence of asbestosis. Exposures had been to amosite and chrysotile, but half or less of worker's time involved exposure to asbestos-containing materials. Time-weighted average exposures to asbestos were below recommended threshold limits (these are now being revised downward). Sources of maximum dust exposure were defined, and control measures recommended.

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EC-00218-03 (Continued)

Studies of sputum samples confirmed asbestos bodies in 32% of the men examined with proportion rising progressively with length of time since first entering the trade. There was no excess of squamous metaplasia, and no new cases of lung cancer were detected by this technique.

Publications: No additional publications.

EC-00220-03 (UI-00436-03)

PHYSIOLOGICAL ASPECTS OF SILICOSIS IN HIGH ALTITUDE WORKERS

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LIMA, PERU

Objectives: This project deals with the physiology of silicosis in miners working at altitudes over 3,500 meters. There is only very scarce information on this subject in the available literature.

Four hundred sixty-three (463) men working inside the mines were examined and 72 were found to be silicotic in different stages of the disease: S_I = 42; S_{II} = 12; S_{III} = 9; Silicotuberculosis = 9. In the state of so called "presilicosis' 39 men were found; however, four of these showed to have definite lung disability, two of them with quite surprising low working capacity.

Physiological studies have been done in 15 cases of P-S and in 8 cases of S_{III}. These studies include:

Total lung capacity (residual volume, vital capacity; timed vital capacity; dead space).
Maximal ventilatory capacity. Respiratory flow/volume correlation. Air distribution in lungs.
Ventilation: at rest and during exercise.
Arterial oxygen saturation: resting and exercising.
Aerobic working capacity: maximal oxygen uptake, maximal pulse rate, lactate production; oxygen debt.

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EC-00220-03
(Continued)

Electrocardiograms: at rest and during exercise.
Blood volume; blood cell counting; hematocrit; hemoglobin.

Data are still far from complete. Blood distribution and V_A/Q ratios, heart catheterization and lung diffusion capacity will be included in future studies.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

EC-00221-04
(UI-00437-04)

IMMUNOLOGICAL STUDY OF THE PNEUMOCONIOSES

ROBERT G. BURRELL
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MORGANTOWN, WEST VIRGINIA

Objectives: This project intends to: 1. Characterize the nature of the lung reactive antibodies in the sera from many types of miners' chest diseases, especially those from coal workers' pneumoconiosis and progressive massive fibrosis. The characterization will include studies of the electrophoretic mobility, molecular weight, and specificity.

2. To continue trying to locate the site of reaction of these antibodies by appropriate IF techniques and thus gain information about the anatomical and chemical nature of the reactive antigens.

3. Assess the role played by these antibodies in the pathological processes by observing effects of antisera on tissue culture systems and on lung function by in vivo injections.

4. Study the immunological responses of animals in which silicosis or coal dust pneumoconiosis has been produced. In particular, the question of the importance of cellular antibodies will be investigated.

5. Continue our correlation studies on the incidence of these antibodies with respect to changes in the disease states, use of chemotherapeutics such as steroids, prognostic and/or diagnostic possibilities, etc.

The overall objective is to study the pathogensis of these occupational hazards from the immunological point of view.

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EC-00221-04
(Continued)

Significant Results: Under this grant it has been learned that:

1. These factors were indeed classical immunoglobulins or antibodies.

2. Furthermore the factors were for the most part of the IgA class.

3. The components in the lung with which these antibodies react were connective tissues, for the most part collagen.

4. The components were not associated with basement membrane (an important antigen known to be involved in certain serious immunologic diseases) except for the collagen contained in the membrane.

5. Only certain serologic procedures may be employed to demonstrate these factors and that it was a waste of time to perform a very common test now in popular usage (using as antigen, latex particles "coated" with crude saline extracts of lung).

6. Experimental silicosis in animals resulted in the production of these same antibodies in a manner similar to humans.

7. Serum IgA levels were significantly elevated in coal miners afflicted with various forms of occupational lung disease.

8. A method for quickly determining the amount of secretory IgA (from saliva) was developed and used to demonstrate:

   a. That people with chronic pulmonary disease had elevated levels of such antibody.

   b. That coal miners with similar afflictions also had elevated levels.

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EC-00221-04 (Continued)

c. That cigarette smoking depressed the level of this substance in the absence of such disease.

Thus it appears that most of the objectives have been accomplished. The most significant, if not most elusive, part of the investigation has been the assessment of the role of these antibodies in developing lung disease.

Publications: No additional publications.

EC-00223-05 (UI-00442-05)

EFFECTS OF AIR POLLUTANTS AND VIRAL AGENTS ON ANIMALS

LEONARD GREENBURG
ALBERT EINSTEIN COLLEGE OF MEDICINE OF YESHIVA UNIVERSITY
BRONX, NEW YORK

Objectives: This project represents an effort to study the histopathological changes in the tracheobronchial tree and pulmonary parenchyma of hamsters and mice resulting from exposure to SO_2 and SO_2 and aerosols of carbon combined. Long term chronic exposures will be made of normal untreated animals, and animals which are co-challenged sequentially with repeated episodes of viral pulmonary disease. A method for rendering hamsters emphysematous has been developed. Emphysematous animals will also be co-challenged with chronic, long-term exposure to SO_2 and SO_2 and carbon and an evaluation of the resulting pulmonary histopathology will be made. The test exposures will be conducted at several environmental temperatures.

Significant Results: Work on the relationship of air pollutants and respiratory diseases in animals has included the assessment of the histopathological effects of a common air pollutant SO_2, on the tracheo-bronchial tree and pulmonary parenchyma of

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EC-00223-05 (Continued)

animals with experimentally induced influenza or emphysema. SO_2 alone even in high concentrations appears to produce minor histopathology in the lungs of Syrian hamsters including focal loss of cilia in the trachea and minor foci of emphysema in the lungs. Animals with virally induced influenza also tolerate SO_2 well and no significant histopathology results from this double challenge.

Emphysema in hamsters is produced by aerosol inhalation of papain, a sulfhydryl protease. The emphysema is of the panlobulor type but without accompanying bronchial obstructive lesions. Animals with emphysema subjected to chronic inhalation of high levels of SO_2 tend to develop, in addition, a condition suggesting chronic bronchitis and bronchiolitis.

Miniaturized equipment for the measurement of lung mechanics in hamsters has been developed and the mechanical properties of the lungs of normal animals, animals with emphysema, normal animals chronically exposed to SO_2 and animals with emphysema chronically exposed to SO_2 have been measured. The static lung compliance in the emphysema groups varied from normal to triple the control value, but the airway resistance measured during natural deflation (R_o) was unaffected. The reduction of flow during forced deflation was moderate and proportional to the reduction of lung recoil. These findings are in contrast to those obtained in human lungs with pulmonary emphysema which invariably show signs of coexisting bronchitis or bronchiolitis associated with an increase of R_o and severe flow limitation during forced deflation. The co-challenge of emphysematous animals with chronic exposure to SO_2 did not significantly affect the elastic lung recoil, the R_o, or the forced expiratory flow except in a few cases, indicating that mild morphologic alteration of the bronchial tree has little functional significance.

Experiments in progress are attempting to produce emphysema with chronic bronchitis in hamsters to more closely simulate the condition seen in humans in order to determine possible additive histopathological effects of chronic exposure to common gaseous air pollutants as well as alterations in lung mechanics.

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EC-00223-05 (Continued)	Publications: No additional publications.	
EC-00224-04 (UI-00445-04)	INVESTIGATIONS OF THE AGING LUNG	MYRON STEIN RHODE ISLAND HOSPITAL PROVIDENCE, RHODE ISLAND

Objectives: Alterations of pulmonary compliance in hyperthyroid patients have been reported by several investigators. However, the mechanism(s) involved have not been clarified, although the observed changes are reversed following successful therapy and restoration of the euthyroid state. The proposed study will investigate the role, if any, of lung surfactant on the changes in pulmonary mechanics in hyperthyroidism. Animals (dogs and rabbits) will be rendered hyperthyroid by daily injections of thyroid hormone. The thyroid state of the animals will be determined by (a) observing weight, (b) pulse rate, (c) BMR, (d) PBI, and (e) RBC uptake of 1-131 triiodothyronine. Lung surfactant will be extracted by previously described methods and measured under conditions of varying surface areas using a modified Wilhelmy balance. The results obtained in the hyperthyroid animals will be compared to those obtained in euthyroid litter mates. When possible, studies of lung compliance and total lung flow resistance will be made prior to extraction of surfactant. Similar studies of lung mechanics and surfactant will be performed in animals made hypothyroid by thyroidectomy. Light and electron microscopy studies of the pulmonary tissue will also be performed to determine the possible role of thyroid hormone on alveolar and bronchiolar cells possibly secreting and/or destroying surfactant.

Significant Results: Investigation of basic concepts underlying the physicochemical properties and physiological rate of lung surfactant have been performed. Lipids from rat and canine tracheal washings by differential centrifugation,

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equilibrium gradient centrifugation, and flotation upon sucrose solutions have been isolated. The preparation obtained exhibited all the usual operational properties of lung surfactant but was devoid of protein and polysaccharide. No surface active lipoproteins or polysaccharides were found.

The effects of concentration and temperature on the performance of lung surfactant on the Wilhelmy balance has also been studied. At low concentrations the hysteresis loops are unstable and collapse with successive cycling, whereas at higher concentrations (above 0.015%), they are unchanged with successive cycling, thus becoming independent of concentration. At room temperatures, wide stable hysteresis loops with low surface tensions are observed on the balance with physiological concentrations. When the temperature is elevated, the hysteresis progressively collapses and can be related to known phase changes that occur in phospholipids. At body temperatures, compressions and expansion surface tensions are nearly identical on the balance, suggesting that a re-evaluation of the physiological role of lung surfactant is needed.

Based on previous observation of lung compliance alterations in hyperthyroid patients, quantitatively harvested lung surfactant from euthyroid and hyperthyroid rats has been done. A significant increase in the quantity of harvested lung surfactant from the hyperthyroid rats was observed and was accompanied by proportional increases in dynamic lung compliance. This represents the first observation of an increased surfactant pool produced by a drug.

Publications: No additional publications.

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EC-00225-04 (UI-00453-04)	METABOLISM OF THE CARBON-CARBON DOUBLE BOND	KENNETH C. LEIBMAN UNIVERSITY OF FLORIDA GAINESVILLE, FLORIDA

Objectives: The aims of this project are:

1. To localize the site of biotransformation in several cases of metabolism of unsaturated compounds which have been previously investigated *in vivo*. Initial series of test compounds will include styrene, indene, dihydronaphthalene, heptachlor and aldrin.

2. To develop *in vitro* enzymic systems of as high a degree of isolation as possible in which these metabolic reactions can be demonstrated.

3. To test for analogous reactions of a systematic group of related compounds, attempting to relate differential characteristics to the reaction to chemical structure of nearby groups.

4. To relate products of the test *in vitro* system to those found *in vivo* as final products of metabolism.

Significant Results: By far the most important result of this grant-supported research has been the elucidation of the pathway of oxidation of unsaturated compounds in mammalian microsomes, which has been shown to occur via the intermediate formation of epoxides that are subsequently hydrated to glycols. In the first years of the work supported by this grant, it had been demonstrated that oxidation with production of glycols was a general pathway of detoxication of unsaturated hydrocarbons in the microsomes of mammalian liver. This reaction was shown to occur with linear alkenes and with cycloalkenes and benzocycloalkenes. In the cases of the cyclenes, the glycol product was always of the *trans*-configuration. As a first step in testing in

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EC-00225-04 (Continued)

the hypothesis that epoxides are intermediates in these pathways, the hydration of epoxides in liver microsomes was demonstrated. In the cases of the cycloalkene oxides, the glycol products were of the same trans-configuration as were those obtained directly from the overall oxidation of the respective cycloalkenes. Finally, conditions were devised that allowed the detection of the very unstable and short-lived epoxide intermediates in the oxidation of three unsaturated hydrocarbons: styrene, cyclohexene, and indene. Epoxides were produced from the alkenes by mixed-function oxidations; the hydration of the epoxides, although occurring in the liver microsomes, were not oxidative in nature. The complete enzymic pathway for the detoxication of unsaturated compounds via epoxides to glycols has thus been elucidated.

Publications: No additional publications.

EC-00226-04
(UI-00454-04)

MESOTHELIOMA IN RELATION TO ASBESTOS

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FAIRLEIGH DICKINSON UNIVERSITY
MADISON, NEW JERSEY

Objectives: The induction of pleural mesotheliomas has been obtained by the applicants in hamsters following intrapleural injection of asbestos of the amosite and chrysotile varieties with harsh (brittle) fibers, while soft chrysotile fibers were not effective. The amount of asbestos used was 25 mg per animal. The proposed experiments will study the carcinogenic effects of the following intrapleural injections in hamsters: (1) brittle versus soft asbestos fibers, using soft chrysotile and both natural and specially produced harsh chrysotile; (2) different dose levels of the varieties known as carcinogenic (amosite and harsh chrysotile) going down from the 25 mg dose previously used to 10 mg and 1 mg; (3) different fiber lengths of asbestos, using material prepared by a wet grinding method developed by the applicants and using chrysotile as well as crocidolite and anthophyllite varieties; (4) materials other than

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asbestos (in 25 mg doses each) including non-fibrous chrysotile, silica, glass wool, talc, diatomaceous earth, aluminum oxide, nickel powder. Groups of 50 hamsters will be used for each test and maintained for 18 months.

Significant Results: Epidemiologic and pathologic studies disclosed increased incidence of pulmonary carcinomas, pleural and peritoneal mesotheliomas in insulation workers. These men are exposed to dusts containing many different substances.

To identify hazardous substances, and thus to provide information for preventive industrial hygiene measures, 22 samples were tested in animals in the present project. It was found that single intrapleural injection of hamsters afforded a convenient test method. After such injections, tumors with characteristics of pleural mesotheliomas arose in response to chrysotile and amosite varieties of asbestos but not in response to talc.

In view of the low solubility of asbestos fibers and their long persistence in tissues, questions arose as to whether measures designed to reduce amounts of exposure could be effective for control of cancer hazards associated with asbestos. Animal tests have shown that cancer response to chrysotile and amosite is dose-related.

Utilizing the hamster-intrapleural test system the following results were obtained.

Tests with two other varieties of asbestos showed that crocidolite was more carcinogenic, while anthophyllite was less carcinogenic, than chrysotile or amosite.

Tumor response to crocidolite was found to be dose related.

Tumor response was reduced or eliminated by reduction in fiber lengths of 3 samples of chrysotiles.

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EC-00226-04 (Continued)

Tumors were induced by 2 samples of diatomaceous earth but not by nemalite or antigorite. Antigorite is chemically similar to chrysotile but is not crystallized in fibrous form.

In addition to various preparations of asbestos and diatomaceous earth, glass fibers are commonly used by insulators. Three samples of glass fibers were tested by the hamster-intrapleural method. One of these samples induced mesotheliomas, the other two did not. These samples of glass fibers differed in physical properties, which may account for the hazard of one and lack of hazard of the others.

Publications: No additional publications.

EC-00227-03 (UI-00461-03)

STUDY OF LUNG STRUCTURE AND FUNCTION WITH AEROSOLS

EDWARD D. PALMES
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NEW YORK, NEW YORK

Objectives: The overall objective of these studies is to make an indirect measurement of the effective size of the intrapulmonary gas spaces of normal subjects and of patients with chronic obstructive lung disease. The method involves the inhalation of monodisperse aerosols and breath holding for varying time intervals up to about 30 seconds. Since the physical properties of the aerosol particles are known, the length of time a particle will remain airborne in a confined space is predictable. By proper choice of aerosol size and time of breath holding, it is hoped that the rate of deposition of the aerosol can be used to establish an index of the size of the intrapulmonary spaces. It is hoped that this can be used as a diagnostic tool in the studies of emphysema or other chronic lung diseases.

Significant Results: Research has led to new information on the fate of aerosols in the human respiratory tract and has given greater insight into the structure and function of the respiratory tract itself. These studies were initiated to investigate one aspect of health effects of the environment of the work place, but the results

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EC-00227-03 (Continued)

have far wider applicability than occupational health alone. For example, the data arising from the program have been used in establishing air quality criteria for particulates. The program also shows real promise in furnishing a new means for the diagnosis of emphysema in man.

Publications: No additional publications.

EC-00228-03 (UI-00465-03)

CHROMOSOME CHANGES IN HUMANS AFTER BENZENE POISONING

ENRICO C. VIGLIANI
UNIVERSITA DEGLI STUDI DI MILANO
MILANO, ITALY

Objectives: The objectives of this project are to study chromosomal patterns in humans exposed to benzene to determine: (1) the frequency of such chromosomal changes, (2) how soon they appear and (3) how long they last after exposure. Three groups of 25-30 subjects each will be studied: (1) a group with histories of benzene-induced bone marrow aplasia, (2) a group chronically exposed to benzene, but without histories of bone marrow toxicity, and (3) a group of randomly selected control subjects of the same age range. A cytogenetic study of lymphocytes cultured from peripheral blood, as well as a complete blood count, will be made every 6 months. When possible a cytogenetic study of bone marrow cells will be performed. The immunologic reactivity of the subjects will be assessed by following antibody levels after vaccination with tetanus toxoid and v. antigen of S. typhi. Total gamma globulins will be determined electrophoretically.

Significant Results: The chromosome study of peripheral lymphocytes and bone marrow cells of people exposed to benzene has shown that: benzene is capable of inducing chromosomal changes of the stable as well as the unstable type. Individuals still suffering from benzene anemia consistently show a higher rate of chromosomal abnormalities; individuals having recovered from benzene anemia may be normal in every respect but usually still show an increased amount of stable and unstable chromosome abnormalities. Individuals exposed to toluene for several years do not show any significant chromosomal abnormality. In one case an acute myeloblastic leukemia

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EC-00228-03 (Continued)

developed in a woman suffering from benzene anemia. During the anemic phase several chromosome abnormalities were found but in the leukemic phase only one type of chromosomal abnormality was present in all leukemic cells, mainly a C-9 trisomy. In another case a benzene anemia was converted into an erythroleukemia, characterized by a chromosome pattern suggestive of breakage and re-arrangement of some chromosomes.

The practical implication of the research is that chromosomal abnormalities are among the earliest signs of chronic benzene poisoning and persist for years after cessation of exposure; the follow-up of the chromosome changes can help in the early detection of the change from benzene aplastic anemia into a leukemic state.

Publications: No additional publications.

EC-00229-03 (UI-00472-03)

TOXICOLOGICAL STUDIES OF OCCUPATIONAL CHEMICALS

S. N. PRADHAN
HOWARD UNIVERSITY
WASHINGTON, D. C.

Objectives: The aim of the project is stated to be to explore the possibility of detecting early manifestations of the toxic effects of some known occupational and industrial chemicals following chronic exposure to them, of determining their maximum acceptable limits by using several conditioned and unconditioned behavioral and neurophysiological methods, and to assess the sensitivity and usefulness of such methods in toxicological studies in general.

The behavioral studies will be conducted on rats. These will include study of effects on spontaneous motor activity; on ability to maintain balance on a rotating rod; on conditioned avoidance (pole climbing), using sound as the conditioned stimulus and electric shock as the aversive stimulus; and on operant conditioning, including (a) shock avoidance by lever pressing and (b) positive reinforcement consisting of the obtaining of water or food contingent on lever pressing using three different schedules.

The neurophysiological studies will be made on cats or possibly dogs. Bipolar electrodes will be implanted in the visual and the auditory areas of the cortex for recording of

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EC-00229-03 (Continued)

EEG in the unanesthetized condition. Both conditioned EEG and evoked EEG responses will be studied. Study of conditioned EEG responses will employ in the cat or dog a procedure described by Ryazanov. Once established, the EEG change may then be elicited without the light by the chemical at levels below that of conscious perception. For study of evoked EEG responses, it is proposed to record evoked responses from the auditory and the visual cortex in response to clicks and flashes of light respectively and study their modification during simultaneous exposure to test substances. Modifications will be determined by submitting the EEG tracings to analysis by some type of average integrator computing device.

Chemicals to be studied initially will be restricted to ones known to produce neurological and/or psychological manifestations, namely organophosphate anticholinesterases, DDT and possibly trichloroethylene. Route of administration may be varied according to the nature of the chemical. Dose or concentration (in case of inhalation) will be quantitatively estimated. Five to 6 animals will be used at each dose or concentration and at least 2 trials will be made in each animal.

Significant Results: The neuropsychopharmacological effects of many of the occupational and industrial chemicals are partially or fully unknown. It was therefore necessary at the beginning to establish a base line for the behavioral effects of certain well-known pharmacological agents using a battery of behavioral and neurophysiological schedules in the experimental situation. Thus arecoline, a muscarinic (m-cholinergic) agent was shown to decrease the spontaneous motor activity, fixed-ratio (FR) water reinforcement and responses in the self-stimulation and shock avoidance schedules. Nicotine (like amphetamine) increased the spontaneous activity, self-stimulation (in a majority of rats) and shock avoidance responses, and decreased FR reinforcements in simple and multiple schedules. Physostigmine, an anticholinesterase, which had both m- and n-cholinergic effects, (nicotinic-cholinergic) decreased the motor activity, FR reinforcement and time-out responses and increased the number of shock in the avoidance schedule along with decrease in the cholinesterase activity.

The m-cholinergic antagonists, e.g., atropine, scopolamine and Ditran (JB 329), caused an increase in the spontaneous motor activity, self-stimulation responses and auditory

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evoked potentials, whereas they caused a decrease in food and water intake and an overall decrease in the various phases of certain multiple schedules of reinforcement (consisting of shock avoidance, FR water reinforcement and time-out). The quaternary analogues of these compounds had very little effects. d-Tubocurarine, an n-cholinergic antagonist, showed a stimulant effect on blood pressure, respiration, somatic reflexes and electrical activity of brain following its injection into the hypothalamus of cats in micro doses.

Investigations were done also with three occupational chemicals: malathion, DDT and hydrazine. Malathion, an anticholinesterase insecticide, tested at doses up to 300 mg/kg showed wide variations in effects on motor activity and self-stimulation and very slight change in brain cholinesterase activity; FR reinforcement was decreased in the majority of the rats. DDT administered to rats on spontaneous motor activity, FR reinforcement and shock avoidance schedules showed tremor and behavioral depression at doses very close to toxic (or near lethal) level. Hydrazine used in the rocket industry (as high energy fuel) decreased spontaneous activity and FR water reinforcement and increased shock in avoidance schedules at doses lower than those needed for histopathological and toxicological studies.

Publications: Pradhan, S. N., "Toxicological Studies of Occupational Chemicals," Progress Report, 59 pp. For period: January 1, 1967 - April 15, 1969. Dated April 15, 1969. Howard University, Washington, D. C.

Pradhan, S. N., Beer, B., Roth, T. and Dutta, S. N., "Some Behavioral Effects of Ditran (JB 329) in Rats," Arch. Int. Pharmacodyn, 170(2), 264-275. (December 1967).

Pradhan, S. N. and Roth, T., "Comparative Behavioral Effects of Several Anticholinergic Agents in Rats," Psychopharmacologia (Berl.). 12, 358-366, (1968). Howard University, Washington, D. C.

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EC-00229-03 (Continued)

Fletcher, A. and Pradhan, S. N., "Responses to Microinjections of d-Tubocurarine into the Hypothalamus of Cats," Int. J. Neuropharmacol (in press). Accepted January 1969. 10 pp. Howard University College of Medicine, Washington, D. C.

Pradhan, S. N. and Dutta, S. N., "Comparative Effects of Nicotine and Amphetamine on Timing Behavior in Rats," Int. J. Neuropharmacol (in press). 10 pp. Howard University, Washington, D. C.

EC-00230-08
(UI-00482-08)

OCCUPATIONAL HAZARDS OF AMINOETHANOLS

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Objectives: The objectives of this study are:

1. To study the biological effects of substituted ethanolamines.

2. To determine the biochemical mechanism by which these materials exert their toxic effects.

3. To study acute inhalation effects and to develop sensitive means of detecting the toxic action of these compounds.

4. To study chronic exposure effects and to define the safe limits of exposure.

The acute oral and intraperitoneal LD_{50} values for a series of alkyl substituted 2-aminoethanols have been determined and this phase of the study is nearly completed. Subacute feeding or injection studies are proposed for selected members of this group.

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specifically monomethyl aminoethanol, n-butylaminoethanol, and ethylaminoethanol. Weight gain, organ weight ratios, liver lipid, hematology, tissue pathology, serum glutamic-oxaloacetic and glutamic-pyruvic transaminase, and blood cholinesterase activity (if warranted by symptomotology) will be determined. Similar evaluation will be made on rats subjected to subacute inhalation studies of four weeks duration. Chronic inhalation studies are proposed for those compounds which preliminary studies suggest may produce a deleterious effect at low levels. The likelihood of industrial exposure will also be a factor in the choice of compounds for chronic testing.

The in vivo effect on serum, red cell and brain cholinesterase activity will be determined in rats receiving i.v. doses of the compounds which will be acutely toxic but non-lethal. The effect of small i.v. injections will be monitored for electrocardiogram, blood pressure and respiration rate. The effect of atropine and neostigmine will be examined. It is proposed to examine the entire series of ethanol amines, and their choline analogues will be studied by these procedures.

Significant Results: Studies to date have resulted in a number of previous publications which define the acute and chronic toxicity of the substituted ethanolamines, by both the oral and inhalation route in experimental animals. Studies on the mechanisms of toxicity culminating in 1969 have shown that 2-N-Dibutylaminoethanol elevations in kidney weight on a chronic basis and on an acute basis results in convulsions in rats leading to respiratory arrest. Artificial respiration can prevent mortality in these acutely poisoned animals. Daily inhalation of 6 ppm of diethanolamine for 13 weeks resulted in elevated lung and kidney weights and some deaths among male rats. On an oral basis, over a 7-week period, the most pronounced effect was a pronounced normocytic anemia.

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Present research on 2-N-ethylaminoethanol and diethanolamine has also demonstrated pronounced cumulative effects on chronic exposure which may necessitate a reappraisal of safety measures for these materials in consumer protection and occupational safety.

The practical significance of these findings is at least two-fold. First, no significant data have existed on the toxicity of a number of these compounds until the present time. Thus no guides have been available to either industry or the consumer on possible hazards from these compounds. The data obtained in these studies are now being utilized by the American Conference of Government Industrial Hygienists to suggest Threshold Limit Values (TLV's) for exposure control. The TLV is a value in parts per million which is suggested as a time weighted average for an 8-hour day. Thus, the published information is being utilized in a practical way to serve as a guide in controlling exposure to these compounds. In fact, the only published data available for setting a TLV for 2-N-Dibutylaminoethanol are the publications resulting from the investigations supported by this research grant.

In addition, a most important finding is that, at least with 2-N-Dibutylaminoethanol and presumably with other compounds in this series, animals can survive multi-lethal doses of this compound if they are maintained by artificial respiration. Thus where a massive over-exposure should occur, the use of a mechanical respirator may be life saving.

Publications: Cornish, H. H., Dambrauskas, T. and Beatty, L. D., "Oral and Inhalation Toxicity of 2-N-Dibutylaminoethanol," American Indus. Hygiene Assn. Journal, 30:46-51, (1969), University of Michigan, Ann Arbor, Michigan.

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EC-00231-08 (UI-00484-08)	PULMONARY DEPOSITION AND CLEARANCE OF DUST IN MAN	ROY E. ALBERT NEW YORK UNIVERSITY MEDICAL CENTER NEW YORK, NEW YORK

Objectives: Using miniature donkeys as experimental animals the investigators seek to construct an aerosol generator capable of producing mono-disperse submicron particles and to characterize the deposition of small particles with different physical properties such as different electrical charges. It is also planned to study the effects of respiratory patterns such as snoring on particle deposition and to determine the basis for two phase bronchial clearance in man, a pattern that is also sometimes seen in donkeys. A study will be made of physiological factors in human clearance including state of hydration, exercise and posture, and the characterization of abnormal particle deposition and bronchial clearance in cigarette smokers and persons with acute, chronic, and congenital lung diseases. In addition, it is intended to produce chronic clearance abnormalities in donkeys, to study the effects of low-level air pollutant exposures on clearance in donkeys and to study the characteristics of bronchial and nasal clearance rates in donkeys using single hot particles.

Significant Results: The study continued in FY 1969 to characterize particle deposition and clearance in the respiratory tract of healthy humans and donkeys, and to determine the effects of various types of lung disease and impairment on these processes. In the human studies, the major effort was directed toward the characterization of normal bronchial clearance, the departures from normal resulting from prior exposure to urban and occupational air contamination and cigarette smoke, and the deviations from normal characteristic of various lung diseases. Additional insight into the nature of the abnormalities has been obtained by comparing the clearance abnormalities observed in man with those which can be produced in donkeys following the inhalation of cigarette smoke and irritant gases.

These studies have been highly productive. Papers published during FY 1969 have provided:

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EC-00231-08 (Continued)

1. A detailed description of the range and variability of bronchial clearance patterns in normal human subjects.

2. A quantitative description of the effect of particle size on the deposition of particles in functional regions of the human respiratory tract, and of the range and variability of regional deposition in normal subjects.

3. A characterization of normal bronchial clearance patterns in donkeys. The studies also established the utility of donkeys as laboratory animals. They can be used for studies of clearance function over periods of up to 10 hours without sedation or rigid restraint.

4. The demonstration of abnormal clearance patterns in donkeys following single acute high-level exposures to respiratory irritants, i.e., sulfur dioxide and whole fresh cigarette smoke.

Additional publications are in preparation, which will describe significant FY 1969 research progress, including:

1. Detailed descriptions of abnormal regional particle deposition patterns and of abnormal patterns of mucociliary clearance in cigarette smokers and patients with lung disease, and of the frequency of such abnormalities in these groups.

2. The determination of a large variability in the time required for recovery of normal mucociliary function in donkeys following exposures which produce immediate effects.

3. The discovery that the nasociliary mucosa of the donkey is much more resistant to the depression of mucociliary transport function by cigarette smoke than the bronchial mucosa.

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EC-00231-08 (Continued)

Publications: Albert, R. E., "Pulmonary Deposition and Clearance of Dust in Man," Progress Report for period April 1966 to April 1968. Dated April 22, 1968. New York University Medical Center.

EC-00232-06 (UI-00485-06)

PYROLYTIC PRODUCTS OF PLASTIC: ANALYSIS AND TOXICITY

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Objectives: The aim of this project is to identify and quantitate the pyrolytic products of certain synthetic resins, and to determine whether these products are acutely toxic when inhaled. Polyvinyl chloride and polyethylene plastics will be used in this study. Pure plastics will be used initially. Later, commercial products containing plasticizers, stabilizers and pigments will be studied. Thermal decomposition temperatures and the products of decomposition will be characterized in a gaseous mixture equivalent to room air and in one representing restricted oxygen supply. Infrared identification and X-ray diffraction will be applied to eluates from gas chromatograms to identify the fractions. Mice and rats will be exposed to the fumes from various steps in the pyrolytic process to determine toxicity. Some survivors will be retained for two weeks following exposure. Others will be killed 24 to 48 hours following exposure. Pathological examinations will be conducted.

Significant Results: There has been increased concern as to the possible toxic effects of the pyrolytic products of plastics on individuals subjected to such exposures. The possibility of such a situation has become more extensive with the greater use of plastics in applications that can result in above normal temperatures (machining operations, bearings, electrical and thermal insulation, etc.). An example of this is their use in aircraft and space vehicles, where large amounts of plastic may occupy a limited closed space.

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Also, in order to dispose of plastics by incineration, it would be helpful to know the combustion products of plastics which are commonly used in disposable goods. With such information it will be easier to determine conditions for complete combustion and problems caused by corrosive or toxic gases could be anticipated and dealt with. Increasing concern with the problem of air pollution makes complete combustion and removal of foreign gases mandatory before releasing incineration products into the atmosphere.

An analytical system for the analysis of the volatile combustion products of plastics has been designed. The system was used extensively to analyze the combustion products of polyvinyl chloride for the purpose of providing analytical information useful to the toxicologist in determining if these products are acutely toxic when inhaled. Recently we used the system with slight modifications to analyze the combustion products of polyphenylene oxide and polyimide film, and are proceeding to polysulfone and polycarbonate polymers.

Generally it has been found that each plastic gives off from 10 to 70 compounds on burning, with several of them being extremely toxic.

Publications: No additional publications.

EC-00233-06 (UI-00487-06)

CARDIORESPIRATORY CHANGES IN AN EMPLOYED POPULATION

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NEW YORK, NEW YORK

Objectives: This project is an attempt to determine the usefulness of the standard respiratory questionnaire and the commonly used pulmonary function tests as predictors

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of the later occurrence of overt chronic respiratory disease. To do this it is necessary to determine:

1. The patterns of change of common respiratory symptoms, of the commonly used pulmonary function values, and of electrocardiographic abnormalities related to pulmonary disease.

In addition, certain subsidiary questions are being considered:

2. The incidence and prevalence of electrocardiographic abnormalities, especially those related to pulmonary disease and their relationship to other indicators of chronic pulmonary disease,

3. The distribution of fractional carbon monoxide uptake and third-quarter-time values in the population and their usefulness in predicting early chronic respiratory disease relative to the tests now commonly used,

4. The usefulness of industrial absenteeism records in predicting early chronic respiratory disease and conversely, the degree to which industrial absenteeism may be predicted on the basis of the tests and standard respiratory questionnaire responses mentioned above.

Significant Results: Preliminary analyses of the data indicate that the electrocardiogram might be a useful tool in screening for chronic respiratory disease. On the other hand the fractional carbon monoxide uptake has been found to be less closely associated with respiratory symptomatology than the simple and commonly used one-second forced expiratory volume. If this finding holds after more extensive analysis, it would appear that the expensive tests of diffusing capacity should not be considered for use in screening programs.

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EC-00233-06 (Continued)	Publications: No additional publications.	
EC-00234-06 (UI-00488-06)	TURPENTINE INHALATION TOXICITY	FREDERICK SPERLING HOWARD UNIVERSITY WASHINGTON, D. C.

Objectives: In this project measurements will be made of the influence of the turpentine exposure on body temperature, EKG, minute and tidal volume. These will be made before and after exposure and the tissue distribution of the inhaled turpentine will be determined by means of gas chromatography. It is proposed to extend the range of turpentine concentrations and the time of exposure to permit a more precise calculation of the LCt_{50} values reported previously. Comparative studies will then be carried out with other lung irritants including SO_2, benzene, isocyanates and halogenated hydrocarbons. A month has been spent at the Heyman's Institute in Belgium learning how to use the Delaunois isolated lung equipment and it is proposed to use this technique to separate alveolar from tracheo-bronchiolar responses of various species to turpentine and other toxic agents. During this period, some preliminary studies were carried out with a modified preparation in which the heart was left intact and it is proposed to continue and extend these studies to determine whether cardiovascular responses can be evaluated in the same system.

Significant Results: Firm experimental evidence was accumulated that turpentine was a potent hepatic microsomal enzyme stimulator and that ingested turpentine was more potent than the inhaled vapors consisting of α and β pinene and Δ^3 carene, the most volatile constituents of turpentine. Oral pretreatment for three days decreased parathion toxicity by as much as one-tenth and increased heptachlor toxicity about 1.7 times. Hexobarbital sleeping time was greatly increased. The effects following inhalation for 3 six-hour days were the same but were not as intense. Microsomes

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from liver homogenates of treated animals showed significant increases in the rates of hydroxylation of hexobarbital and of p-aminophenol and in the rate of demethylation of aminopyrine. These effects may have importance with regard to effects on insects and wildlife in an evergreen forest environment, and with regard to human reactions to drugs after exposure to high concentrations of turpentine.

In a second series of experiments, the profound peripheral pulmonary effects of barbiturates on the isolated lung were related to retention by rat and guinea pig lungs, after a single dose of high concentrations of each drug. The slow, progressive release of phenobarbital, hexobarbital and thiopental were similar, but the high concentrations of pentobarbital remained unchanged for about four hours. The persistent high concentrations may explain the failures of therapy in cases of massive overdoses of barbiturates.

Publications: Sperling, F. and Marcus, W., "Turpentine Induced Histological Changes in Isolated Rat and Guinea Pig Lungs," Arch. Int. Pharmacodyn, 175(2), 330-338, Howard University College of Medicine, Washington, D. C.

Sperling, F., Marcus, W. L. and Delaunois, A. L., "Responses of Isolated, Perfused Rat and Guinea Pig Lungs to Barbiturates," Arch. Int. Pharmacodyn, 176 (2), 309-318, (May 8, 1968). Howard University of Medicine, Washington, D. C.

Marcus, W. L. and Sperling, F., "Comparison of *in vitro* and *in vivo* Concentrations of Thiopental and Hexobarbital in Guinea Pig Lungs," Federation Proceedings, 28 (2). (March-April 1969) Howard University Medical School, Washington, D. C.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00235-04 (UI-00493-04)	OCCUPATIONAL HEALTH SERVICES IN SMALL INDUSTRIES	A. WALTER HOOVER BROOKDALE HOSPITAL CENTER BROOKLYN, NEW YORK

Objectives: This project has as its purpose the establishment of a hospital-based Occupational Health Program designed to serve over 1400 small industries within the immediate service area of a general hospital. The project is located on the physical premises of the Brookdale Hospital Center and is conducted under the supervision of the Division of Occupational Medicine of the Columbia University School of Public Health and Administrative Medicine.

The occupational health needs of the area are being determined by a survey procedure. At present, the project is serving a group of 45 small industries with a total employee population of approximately 4,000 with a complete range of occupational health services, including the care of industrial injuries, multiphasic screening, health counseling, industrial hygiene tests and part-time, in-plant nursing services.

The program was designed to be integrated after five years into the departmental structure of the hospital to meet the existing needs of the heavy concentration of small industries in the area. To foster implementation of the integration process, cost factors and utilization levels necessary for self-sustaining operation are being investigated.

Significant Results: At the onset of this project there was considerable doubt that the bad image of the hospital would help in any way to establish a relationship with outside industries. It was found that by the use of a professional interviewer and a questionnaire designed especially for this purpose that industries were willing to give information in fairly great detail and that the questionnaire itself served to advertise services in a completely ethical manner which did not evoke objections from the organized medical profession in the area.

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Prior to the establishment of the occupational health program at Brookdale Hospital, industries in the area had access to only a few general practitioners, but for the most part were already dependent on the hospital for accident care in the emergency room which was accomplished with excessive delays due to the existing priority system. Less than 5% of the industries in the area had any relationship with a private physician. No industries of the 1,600 in the area had access to even part-time nursing services.

It has been found that it is possible to develop a single occupational health service to serve both a large hospital employee group of 1,600 employees and a selected segment of an outside employee group in the immediate area of approximately 35,000. Acceptance of accident care and pre-employment examination has been good and now there is an evolution of interest in executive physical examinations and other periodic examinations. None of the services are rendered free of charge. An effort has been made to calculate the cost of each examination or procedure and to charge outside industries at this level. This has been difficult because of the practically non-existent cost accounting procedures in the hospital itself. In spite of these impediments the occupational health program is rapidly becoming solved on a break-even basis.

Publications: No additional publications.

EC-00236-09 (UI-00494-09)

THE USE OF INFRARED SPECTROSCOPY IN CLINICAL ANALYSIS

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Objectives: The purpose of this project is

1. To investigate possible methods for the concentration and separation of volatile organic compounds in the exhaled breath prior to analysis by infrared spectroscopy,

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mass spectroscopy, or gas chromatography. Methods planned include (a) selective condensation, (b) the use of molecular separators for components of widely differing molecular weights, (c) adsorption using a solid adsorbent.

2. To investigate concentration and analytical techniques for determination of very small amounts of toxic metal ions in water, blood, and urine. This will be accomplished either by use of ion exchange resins or of electroplating techniques.

Significant Results: The overall purpose of this research has been to develop clinical laboratory methods for the determination of organic compounds in biological systems in the "part per million" range, by utilizing recent developments in instrumental analysis. The first specific aim was to determine the acetone concentration in the expired air, blood, and urine of diabetic patients in acidosis for the purpose of rapidly defining the degree of ketosis. In using this method to establish the degree of ketosis, it was evident that it would be desirable to establish the amount of acetone in the breath of both the controlled diabetic and the nondiabetic. More than 800 determinations were made on 169 subjects. The data were statistically analyzed by computer methods to correlate the variation of acetone with various parameters (urine sugar, urine ketones, age, sex, etc.). This work pointed out that the expired air acetone value did provide clinically useful information in the diabetic subjects studied in this preliminary investigation.

The second aim of the program was to determine whether the same techniques might be used for the detection of commercial solvents in the exhaled breath of industrial workers for the purpose of establishing both the type and magnitude of the exposure. In order to do this, it has been necessary to develop the methodology and to determine the sensitivity of both the gas chromatograph and the infrared spectrophotometer. These sensitivities were determined for 16 of the common halogenated hydrocarbons.

Publications: Boettner, E. A., "The Use of Infrared Spectroscopy in Clinical Analysis," Progress Report. Parts I and II for period: May 1, 1966--August 1, 1968, dated August 1, 1968. Includes 2 reprints. Part I - "Animal Breath Data for Estimating the Exposure of

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EC-00236-09 (Continued)	Humans to Chlorinated Hydrocarbons." and Part II - "Water Analysis by Atomic Absorption and Flame Emission Spectroscopy," University of Michigan.	
EC-00237-03 (UI-00497-03)	RELATION OF SMOKING TO NEOPLASIA IN ASBESTOS WORKERS	IRVING J. SELIKOFF MT. SINAI SCHOOL OF MEDICINE OF CUNY NEW YORK, NEW YORK

Objectives: Preliminary observations in prospective studies of a sample of asbestos insulation workers have suggested that the occurrence of bronchogenic carcinoma among them has been largely limited to individuals with a history of cigarette smoking. While asbestos workers who do not smoke cigarettes may also have an increased risk of bronchogenic carcinoma--and other neoplasms--the preliminary data indicate that the very great excess of neoplasia-risk, which has been asbestos lung cancer, perhaps the most important industrial cancer at this time, is highly related to cigarette smoking.

This new research is based upon a prospective study of 18,000 asbestos insulation workers throughout the United States, to test the preliminary observations. If they are found to be accurate, the information will be available for incorporation into industrial hygiene and public health programs designed to eliminate or diminish the risk of bronchogenic carcinoma and other neoplasms among workmen exposed to asbestos.

Significant Results: This investigation includes the close cooperation of the Asbestos Workers Union (the International Association of Heat and Frost Insulators and Asbestos Workers, AFL-CIO). The health experiences of its 17,000 members are being studied, prospectively, from January 1, 1967.

From that date to December 31, 1969, approximately 750 deaths occurred among members of this Union. Each is being carefully analyzed. Deaths which will occur during 1970 will be similarly studied.

The data obtained will serve to accurately define the nature and extent of the hazards involved, and will point the focus for the practical corrective measures now being developed.

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In addition, clarification of the special influence of cigarette smoking among asbestos workers is being documented, and such definition will serve to develop recommendations that may lead to the marked reduction of lung cancer deaths among asbestos workers.

Publications: No additional publications.

EC-00238-02 (UI-00498-02)

IN VITRO STUDIES OF OCCUPATIONAL DERMATITIS

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SEATTLE, WASHINGTON

Objectives: This project proposes development of in vitro tests for detection and quantitation of contact sensitivity. The basic protocol consists of the lymphocyte transformation system and guinea pigs sensitized to 2, 4- DNCB and DNCB--skin protein conjugates. The endpoint will consist of counting proportion of blast cells after appropriate in vitro incubation as well as incorporation of tritiated thymidine. Ultimately, the applicant plans to adapt his findings in the guinea pig to humans, taking advantage of some 100 individuals in the Seattle area previously sensitized to DNCB by other investigators.

Significant Results: Presently, the only method of diagnosis is a 70-year old test (the patch test) which is hazardous in several respects. A way has been developed to diagnose contact dermatitis in the test tube--the first advance in diagnosis in this disease in the 20th Century.

This test will enable physicians to diagnose this disease without:

1. Inadvertent sensitization of the patient
2. Spreading the dermatitis and causing massive sensitization
3. Requiring the patient to make several visits for testing and evaluation
4. The inaccuracies inherent in the old "patch test."

Publications: None

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EC-00239-02 (UI-00505-02)	HEALTH HAZARDS OF THE DI-ISOCYANATES	JOHN M. PETERS HARVARD UNIVERSITY BOSTON, MASSACHUSETTS

Objectives: The objective of this proposal is to examine the possibility of a relationship between exposure to di-isocyanates and the subsequent development of acute and chronic respiratory disease. This will be done primarily by examining workers currently exposed to low levels of toluene di-isocyanate (TDI) or who in the past have suffered from acute intoxication with this material.

Significant Results: A study has been made of workers engaged in oolyurethane plastic manufacture. It has been determined that toluene di-isocyanate (TDI) in air concentrations below the TLV causes acute changes in ventilatory capacity which do not recover overnight. Workers who have cough and sputum show a greater reaction to this material than asymptomatic ones. It has also been determined that cumulative changes in ventilatory capacity occur over time which exceed those expected from aging. The acute changes predict the cumulative changes to a considerable degree ($r = 0.72$). It is believed that findings indicate that TDI constitutes a hazard as regards chronic lung impairment. It is also believed that the current TLV (0.02 ppm) is too high.

It has been determined that there is a correlation between peripheral blood eosinophil levels (absolute counts) and the acute change in ventilatory capacity. Also it has been possible to demonstrate that potentially toxic exposure to isocyanates can occur through the innocent use of commercially available "instant" polyurethane products.

The practical significance of this is that a new occupational cause of chronic lung disease has been discovered and with the increasing use of polyurethane plastics.

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EC-00239-02 (Continued)

more and more workers will be exposed to TDI. Techniques have been determined by which the effects can be assessed and susceptibles can be screened out. As a by-product the presently accepted TLV of 0.02 ppm seems to be high and should be lowered to protect the worker.

It is also obvious that the consumer should be prevented from exposing himself to TDI in his basement or workshop as serious acute effects (asthma) can occur from the use of the new "instant" foams.

Publications: Peters, J. M., Mead, J. and Van Ganse, W. F., "A Simple Flow-Volume Device for Measuring Ventilatory Function in the Field," (Results on Workers Exposed to Low Levels of Toluene Diisocyanate), American Review of Respiratory Disease, 99 617-622 (1969) Harvard University School of Public Health, Boston, Massachusetts.

EC-00240-04
(UI-00507-04)

INHALED ASBESTOS AND PULMONARY CANCER AND PLEURAL MESOTHELIOMA

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WAYNE STATE UNIVERSITY
DETROIT, MICHIGAN

Objectives: This program outlines an extensive experimental investigation of the biological effects of various types of asbestos fibers on the respiratory system. The three main types of asbestos (amosite, crocidolite and chrysotile) will be tested for their relative capacity to produce asbestosis and for carcinogenic effects. The following areas will be studied: (a) the chemical and physical nature of the various forms of asbestos and the possible presence of extractable carcinogens; (b) long term biological tests, mostly in hamsters, using large inhalation chambers as well as the intratracheal instilliation technique for special studies; (c) histogenesis studies of the induced pulmonary lesions by serial sacrifices; (d) studies of the localization and migration of the asbestos fibers in the respiratory organs

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EC-00240-04 (Continued)

with particular regard to their particle size and to their relation to the induced lesions; (e) histochemical studies of the induced tumors, particularly for the differential diagnosis of induced mesotheliomas; (f) transplantation studies of the induced neoplasma and (g) biochemical studies of lung tissue from natural and asbestos-treated lungs including nucleic acid analysis, electrophoresis studies of proteins and mucoids and a series of enzyme determinations (acid phosphatase, hyaluronidase, LDH).

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

EC-00293-02 (UI-00702-02)

EXTRACTION OF METAL COMPLEXES BY PROPYLENE CARBONATE

B. G. STEPHENS
WOFFORD COLLEGE
SPARTANBURG, SOUTH CAROLINA

Objectives: The aims of this project are:

1. To establish propylene carbonate as an analytical extractant of general utility.

2. To develop better methods for the trace determination of several elements.

The primary emphasis is on the possible utility of propylene carbonate as an extractant for various metal complexes prior to their determination by spectrophotometry, polarography and atomic absorption spectrophotometry. Also stressed is the lower toxicity of propylene carbonate than that of other commonly used extractants. The material is stated to be apparently non-toxic by mouth or skin absorption, according to a technical bulletin of the Jefferson Chemical Company.

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EC-00293-02 (Continued)

The method of procedure will be to investigate the solvent as an extractant for several chelated and ion-associated chelate systems. The effect of hydrogen ion, complexing agents, interfering ions and masking agents on the extractability of each system will be studied. A list of systems to be investigated included some 30 elements all of which apparently are scheduled for investigation. An example of the detailed plan is given for the nickel (II)--dimethylglyoxime complex. The extraction of the complex at various concentration levels and in the presence of a variety of other elements and masking agents will be carried out. Since this particular compound is colored, colorimetric methods will be used for the final estimation whereas with the others, other methods might be employed.

The significance of this research is that several toxic solvents commonly used in analytical chemistry will be replaced by one which is relatively non-toxic. In addition, the new solvent should improve the analytical procedures themselves.

Significant Results: During FY 1969 work was completed on the extraction of several metal chelates into propylene carbonate. Methods and procedures for the quantitative determination of the metallic elements, uranium, cobalt, iron, and copper were worked out in considerable detail. Uranium was selectively extracted into propylene carbonate as the uranyl-dibenzoylmethane complex. Cobalt was extracted as the 1(2-pyridylazo)-2-naphthol and the 2,2',2"-terpyridyl complexes. Iron was extracted as the acetylacetone complex and copper as the neocuproine complex. The concentrations of metal chelate in the propylene carbonate extract were determined colorimetrically. Additionally, the concentrations of the iron-acetylacetone complex were determined polarographically and atomic absorption spectrophotometrically.

Publications: None

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EC-00306-02 (UI-00766-02)	LONG-TERM STUDY OF BERYLLIUM DISEASE	HARRIET L. HARDY MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS

Objectives: This project has three objectives: to improve criteria for correct diagnosis; to develop clinical evidence to support the concept that beryllium poisoning is a systemic intoxication with a variety of complications including malignancy; and to seek alternate forms of treatment and assess the hazards of long-term use of steroids.

Studies will be made of the content of beryl and beryllium in normal tissues and tissues of patients with sarcoidosis, tuberculosis and other diseases, as well as in patients with beryllium disease. If promising leads come from a proposal of Newberne's, urinary beryllium levels will be measured in cases of beryllium disease. By collaboration with Schroeder, the background levels of beryllium in food, water and soil will be assessed. Patients with chronic beryllium disease will be examined for evidence of other systemic manifestations of the disease and comparative studies with sarcoidosis will be made.

Data from the Beryllium Registry now in MIT computer facilities will be further processed. This would aid in refinement of diagnostic criteria and supply detail on clinical correlations and presently documented complications.

The benefit-risk ratio of steroid therapy will be examined. Immunosuppressive drugs will be tried as alternate therapy in patients who are not responding to steroids. Lung function studies will be made on patients with beryllium disease.

Significant Results: In animal experiments beryllium causes cancer of lung and bone. Studies show that some beryllium remains in the body for long periods, up to 20 years

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EC-00306-02 (Continued)

after last exposure and thus may act to provoke cancer. Studies are being made of epidemics to discover whether or not beryllium may cause human cancer. A main goal is to recognize beryllium caused cancer. If the beryllium from coal burning proves capable of causing disease, the possibility of beryllium cancer from atmospheric pollution becomes a matter of grave importance.

Publications: None

EC-00310-01 (UI-00833-01)

PHYSIOLOGIC RESPONSES TO WORK STRESS IN STEEL WORKERS

DAVID MINARD
UNIVERSITY OF PITTSBURGH
PITTSBURGH, PENNSYLVANIA

Objectives: In this project physiological strains in steel workers imposed by stresses of heat exposure and muscular work will be assessed by analysis of heart rate patterns derived from tape records of ECG recorded continuously on subjects and controls during the work shift. Changes in body weight and body temperature will be measured at suitable intervals as supplementary criteria of strain. Preliminary studies on six test subjects reveal suggestive relationships between mean and peak levels of heart rate recorded during stressful work and the maximum aerobic capacity estimated from heart rate responses to submaximal work on a bicycle ergometer before the work shift. In the project proposed here these pilot studies will be extended to include measurement of heat tolerance as an independent variable as well as to investigate the presence and extent of decrement in aerobic work capacity after the work shift as an index of physiological fatigue.

A new generation of physiological monitors designed for minimum inconvenience to the subject will be evaluated in parallel with the tape monitor as the means for integrating

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EC-00310-01 (Continued)

significant data on heart rate, body temperature elevation, and disorders of cardiac rhythm. The immediate aim of this study is to provide occupational health professionals with valid physiological criteria for assessing job demands and for matching these to the physiological capacities of the worker.

Significant Results: ECG, heart rate, sweat rate and changes in body temperature were monitored in workers performing jobs in the open hearth department of a large steel mill in Pittsburgh. These responses were used to evaluate the degree of physiologic strain imposed on the cardiocirculatory and thermoregulatory systems of the body by stresses of physical work and exposure to heat.

During the summer of 1969 peak heart rates in some workers were observed to be as high as 190-200/min. with body temperature elevations up to 38.8°C. Sweat rates averaged 0.62 L/hour. Furnacemen utilized an average of 38 percent of their maximum cardiocirculatory capacity on the job compared with 13 percent during leisure working hours off the job.

Individual workers varied widely in their ability to tolerate work stress. In six test subjects the mean heart rate during the entire shift ranged from 97/min. to 136/min. in different individuals. Work capacity was estimated by direct recording of ECG and heart rate while the subject performed standard submaximal exercise at 125 watts on a bicycle ergometer in a comfortable environment. The heart rate attained after 5 min. was found to predict how well the subject would perform on the job. By comparing his performance during the standard exercise after the shift with his performance before the shift began, one could judge the degree to which his work capacity had been impaired by physiological fatigue during the work shift.

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EC-00310-01 (Continued)

Computer analysis is being used to analyze the role of factors in the work environment (time spent at different tasks and in different locations) causing variable degrees of strain and fatigue in the same individual on different shifts, as well as personal factors (age, physical fitness, acclimatization, water and salt intake) which determine variations in tolerance to stress of different individuals performing the same jobs.

It is expected that the information now being obtained will provide criteria for setting standards for industrial exposures to work effort and to heat stress, and for the selection of workers. Such standards are necessary to prevent short- and long-term health impairment from cumulative effects of excessive physiologic strain.

Publications: None

EC-00313-02
(UI-C0849-02)

ASBESTOS DUST, THEIR PATHOGENIC COMPONENTS

PAUL GROSS
INDUSTRIAL HYGIENE FOUNDATION
PITTSBURGH, PENNSYLVANIA

Objectives: This investigation has as its aim the study of the biologic or tissue reactive effects of asbestos fibers both with and without various contaminating substances which may be admixed with it in processing. These include several heavy metals and hydrocarbons. It has been the interesting experience to observe that in experiments chrysotile fibers prepared in a metal ball mill were considerably contaminated with nickel, chromium and cobalt and produced a "high prevalence of lung cancers" in rats, while fibers not so contaminated did not produce malignancies. Other data similarly suggest that asbestos fibers may be contaminated, and that the contamination material may be suspected as the neoplastic promoting agent. The experimental plan is simple and adequately detailed. Rats age, weight or strain unspecified, will be utilized in a study of the inflammatory (300) and neoplastic (600) potentials of the substances under study in the lung, and rats and hamsters (300 each) will be used in an intrapleural injection experiment devised to study the possibility of mesothelioma production. The dusts used (each of three forms of native asbestos: chrysotile, amosite and crocidolite) will be gathered from unnamed suppliers,

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EC-00313-02 (Continued)

probably Canadian and American, and prepared in five ways: (1) positive control (i.e., asbestos fibers treated in a metal contaminating hammer mill); (2) negative control (asbestos fibers treated in a perspex coated mill so no metal contamination occurs); (3) asbestos prepared as in (1) but treated by aqua regia and chelating agents to free the dust of metallic contaminants; (4) asbestos prepared as in (1) but treated by heat to free the fibers of hydrocarbon contamination; and (5) asbestos fibers prepared as in (1) but treated by the aqua regia/chelating process and heat to remove both groups of contaminating materials.

Significant Results: A working hypothesis is that carcinogenic potential of asbestos dust resides in the trace metals present.

In order to test this hypothesis, it is planned to add to synthetic chrysotile (which has proven itself biologically "inert") insoluble compounds of these trace metals. These trace metals with their carrier, when injected into the lungs, were expected to remain as life-long deposits in the lungs and their prolonged contact with the tissues was to provide maximum opportunity for the trace metals to exert their carcinogenic action.

The trace metals chosen for this purpose were nickel, chromium, cobalt and manganese. These were injected intratracheally into rats as oxides and/or phosphates.

No lung cancer developed in any animal. It is believed that the reason for this failure resides in the insolubility of the oxides and phosphates, which did not allow for sufficient elution to irritate the tissues.

The investigation is continuing with less insoluble compounds of the trace metals.

Publications: None

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EC-00314-01 (UI-00850-01)	LUNG CELL FUNCTION: HEALTH AND INHALED HAZARDS	EUGENE D. ROBIN UNIVERSITY OF PITTSBURGH PITTSBURGH, PENNSYLVANIA

Objectives: The aim of this project is to study the energy metabolism in relation to ion, water, and particle movements across the membrane of alveolar macrophages (of rabbit and man) and mesothelioma cells (man). One of the major objectives is to determine whether, and the mechanisms by which, noxious substances (nitrogen dioxide, asbestos, silica) change these parameters.

This broad approach to characterize alveolar macrophages will be approached first by measuring in normal cells: steady state sodium, potassium, chloride and water contents; membrane potential difference; sodium-22 and potassium-42 fluxes and the effects of ouabain on these fluxes; rate of net sodium, potassium and chloride efflux when the alveolar macrophage is suspended in media not containing these ions; and total and sodium-potassium activated adenosine triphosphatase. Then it is planned to determine changes in many of these parameters during phagocytosis of killed bacteria. Similar studies are planned in the presence of metabolic inhibitors (antimycin, cyanide, 100% nitrogen, iodoacetate); a phosphate buffer will be used, since cyanide inhibition of respiration is never complete in phosphate buffer, its use will permit the use of their interpretation that a non-cytochrome oxidase pathway for oxygen consumption is present. A major emphasis will be given to changes in alveolar macrophage potential differences in anoxia, etc. In the study of noxious agent effects, the measurements will be of ion movements and energy metabolism (metabolism of substrates and adenosine triphosphate production, etc.).

Significant Results: Methods have been developed for determining the oxidation-reduction state of the cytoplasm and mitochondria of macrophages. Since many pollutants are either strong oxidants or reductants, it is hoped that these measurements

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EC-00314-01 (Continued)

in isolated cells exposed to some of the pollutants will provide an understanding of the nature of cell damage induced by them.

Study of the effects of oxygen lack on cell function is being done. O_2 depletion is a common feature of various types of lung disease. It appears that hypoxia produces striking alterations of cell structure, electrolyte composition and electrolyte regulation. These factors operate in the direction of rendering the lung more susceptible to infection.

Study is also being done of the mechanisms by which pollutants and particulates cross the cell membranes of the macrophages. Results show that for a number of materials, the cell acts as a concentrating device. This work is at a preliminary stage but may provide understanding of the relationship between exposure and cell damage.

Study is being done of the intimate biochemical mechanisms involved in phagocytosis. Since this is the final step involved in the elimination of particulates within the lung, these data may provide basic insight into this aspect of lung function.

These studies will help provide some basic background upon which intelligent planning with respect to prevention and treatment of lung disease related to pollutants must be based.

Publications: None

EC-00315-02 (UI-00852-02)

EFFECTS OF CARBON MONOXIDE ON HUMAN AND ANIMAL BEHAVIOR

RODNEY R. BEARD
STANFORD UNIVERSITY
STANFORD, CALIFORNIA

Objectives: This proposal aims at refinement of methodology for detecting minimal effects of air pollutants, in particular carbon monoxide, by assessing non-symptomatic

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EC-00315-02 (Continued)

changes in behavior. With these techniques an attempt will be made to provide information to be used as a guide in establishing standards for limits of CO in air. It is pointed out that heretofore studies of CO effects have dealt with acute exposures and have focused upon physiological changes. In the basic experiment on humans, psychophysical tests will be administered during a baseline period, during exposure to CO and during a brief post-exposure period. Carbon monoxide will be metered into the test chamber at such a rate as to reach steady state concentration in either 2, 10 or 30 minutes. Exposure times for humans will range up to 90 minutes, at concentrations up to 250 p.p.m. Clearing time will be 12 minutes. Subjects will be assigned to cells of a Latin square design. Baseline CO levels of human S's will be obtained by breath analysis. In animal studies blood samples will be taken and analyzed for carboxyhemoglobin concentration. Psychophysical visual tests on humans will measure absolute visual threshold, relative visual threshold, visual acuity and critical fusion frequency. Temporal discrimination will be determined by requiring comparison of durations of two auditory or two visual signals using the method of constant stimuli for difference thresholds. Other experiments will compare the effects of CO on judgment of "filled" versus "empty" time intervals. The effect of CO on multiple choice performance of graded levels of complexity will also be assessed using a modification of the Discrimination Apparatus for Discrete Trial Analysis; a PDP-8 computer is used to simulate the performance of this instrument. In a variation of this test, the responses to sequences of graded complexity will be measured, i.e., the subject will have to learn chain sequences in which the number of possible responses and the number of links are varied. Data will be analyzed for particular strategies and patterns of error, number of chains completed, errors per chain, learning time per chain, etc.

The animal experiments will concentrate on free operant conditioning methods with both appetitive and aversive reinforcement using various appetitive reinforcement schedules, including delayed response. These will be applied in such a way that performance becomes implicitly a function of the animal's internal clock and hence becomes a measure of temporal judgment.

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EC-00315-02 (Continued)

Data will be subjected to analysis using a home-developed special-purpose computer designed to accomplish on-line, real-time determination of serial periodicities and sequential dependencies. Emphasis is placed on sequential analysis with special attention to conformity with mathematical models.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: None

EC-00334-01 (UI-00970-01)

BIOLOGIC ASPECTS OF HOST FACTORS IN ACCIDENTS

GORDON G. GLOBUS
UNIVERSITY OF CALIFORNIA
IRVINE, CALIFORNIA

Objectives: This proposal seeks to investigate rhythmic variation in efficiency of behavior which pertains to biologic mechanisms underlying host factors relevant to accidents, particular at clock times which are characteristically associated with sleeping. Specific hypotheses to be tested are that (1) behavior on a number of perceptual, cognitive and psychomotor performance tasks studied all night long will show rhythmic variation over time, and (2) clock times of maximal impairment in these waking behaviors will be coincident with clock times associated with the occurrence of D-State ("Rapid Eye Movement Sleep") onset during sleep. It is hypothesized that some of the variability in these waking behaviors over time can be attributed to an underlying sub-circadian biorhythm which is clock time locked and a reflection of a third basic organismic state, the D-State, which ranks in importance with waking and sleeping states. Clock times of maximal impairment will be identified which are crucial for specifying work-rest cycles that are optimally safe, especially for driving at night, under conditions of staying awake all night, awakening from deep sleep and one prior night's sleep deprivation. In addition, a

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rapprochement between the burgeoning fields of accident research and sleep research will be provided.

Significant Results: The study of performance on tasks such as operating a machine or driving a vehicle over many hours generally assumes that performance decreases in a linear fashion, i.e., the longer on the task, the greater is the impairment of performance, presumably due to such factors as fatigue, monotony, decreased motivation, and the like. The present study is designed to look at ups and downs in performance, or "performance cycles", over many hours on a task. Preliminary data suggest that performance does tend to increment and decrement in a cyclical fashion, with the length of the cycle varying with the time of day. A study has been made of night workers-day-sleepers on daytime performance after a few hours sleep and note cycles from 60 to 90 minutes in duration. Day workers-night-sleepers studied at night show cycles from 90 to 110 minutes in duration. Measures of performance include tasks requiring sustained attention, fast reaction time, and complex motor behavior. Some data suggest that the same kinds of cycles so easily detected in sleep as rhythmic changes in brain wave patterns are detectable in the waking subject in terms of his performance.

The practical significance of this research relates to the scheduling of work-rest units so as to maximize performance and minimize accidents. Rather than the work unit being a standard 60 minute unit, research may suggest new work units based on biological factors (biological rhythms) which vary with time of day. For example, a 60 minute work-rest unit may be appropriate in the morning whereas a 100 minute work-rest unit may be appropriate in the evening. As the crucial factor in determining the cycle in performance seems to be a dimension of the subject's feeling more or less active, i.e., an activity-rest cycle, research is relevant to individuals falling asleep while performing a task, i.e., at the wheel of a car.

Publications: None

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EC-00335-08 (UI-00667-08)	EPIDEMIOLOGY OF PHYSIO-PATHOLOGY OF "FARMER'S LUNG"	JOHN RANKIN UNIVERSITY OF WISCONSIN MADISON, WISCONSIN

Objectives: The research plans of this project include studies directed toward the following: (1) identity and source of the antigens involved; (2) immunology, pathology and epidemiology of related clinical syndromes; (3) development of an animal preparation suitable for immuno-pathologic investigations utilizing tagged antigens and antibodies; (4) contingent on the successful development of satisfactory animal preparation, electron microscopic studies of the events in the lung immediately following an inhalational challenge with the appropriate antigen.

The antigens responsible for this t[illegible] of immunopathologic reaction are ubiquitous and are likely, therefore, to be the c[illegible]f a significant amount of illness and disability in a rural population. E[illegible]gic surveys to determine the prevalence of these disorders are being condu[illegible] the technical assistance of the Wisconsin Survey Research Laboratory.

Significant Results: There is no sig[illegible]ficant difference in FY 69 from that in FY 68.

Publications: Kobayashi, M., Barbee, R., Rankin, J. and Dickie, H., "Pulmonary Granulomatoses Due to Inhaled Organic Antigens," Medical Clinics of North America, 51, No. 2, 459-482, (March 1967), University of Wisconsin School of Medicine, Madison, Wisconsin.

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EC-00336-01 (UI-00974-01)	SECOND LASER SAFETY CONFERENCE	LEON GOLDMAN UNIVERSITY OF CINCINNATI CINCINNATI, OHIO

Objectives: This was a two-day conference (March 24 and 25, 1969) designed to present the current status and trend of developments and research work in laser instrumentation and on health hazards thereof. This conference consists of lectures, demonstrations, discussions and workshops.

Significant Results: New information gained from the Conference was (1) knowledge of new Laser system; (2) correlation of Laser safety data from different sources; and (3) first introduce the subject of concern to the public with the atmospheric propogation of laser.

Items of practical significance were:

1. Considerable data given to all the Z-136 Laser Safety Committees of A.N.S.I. (American National Standards Institute).

2. Recommendations for detailed studies on the hazards of atmospheric propagation of laser systems for air craft pilots and passengers and the general public.

3. Recommendation for establishment of an Institute of Laser Biology and Medicine.

4. Set up the goals and program outline for the next Laser Safety Conference in 1971.

Publications: None

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EC-00337-01 (UI-00982-01)	EXPERIMENTAL PATHOLOGY OF AIR POLLUTION	HOLLIS G. BOREN MARQUETTE SCHOOL OF MEDICINE MILWAUKEE, WISCONSIN

Objectives: The aim of this project is to study the effect of noxious gases, particularly NO_2, on rate of turnover in pulmonary cells. Plans are to establish baselines and then do short term studies with exposures to carbon and nitrogen dioxide combined and in various sequences. Also to evaluate the effects of NO_2 and carbon combined and in different sequences on pulmonary surfactant. The technique planned to use for this purpose entails the use of deflation pressure volume curves. These curves are obtained on preparations of the lung and surrounding thoracic structures. In addition, the effects of inhaled noxious materials on the oxygen uptake of these lung-thoracic structure preparations will be investigated.

Also it is planned to carry out electron microscopy studies of the effects on pulmonary tissue of administration of carbon and nitrogen dioxide in combination and in various sequences.

Significant Results: A group of male hamsters was exposed to a low concentration of cigarette smoke from four cigarettes every six hours for 48 hours. Cigarette smoke was diluted 150 times before the animals were exposed to it. The particle concentration was measured by a forward light scattering photometer and was 58 mcg liter mean for a 30 second burn of cigarette. Animals were killed serially during the exposure period and for 72 hours after the end of exposure. Counts of labeled cells in pulmonary airways and alveoli after a single dose of H^3-Thymidine were compared with counts from a group of normal hamsters. After the first exposure to

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EC-00337-01 (Continued)

the smoke from four cigarettes, increased labeling of cells was found in bronchi, bronchioles, and alveoli. In the conducting airways, the highest counts were in bronchioles with less than 200 μ minimal diameter, least in bronchi with minimal diameter greater than 400 μ, and intermediately elevated in bronchi having 200-400 μ minimal diameter. After the first peak at eight hours, labeling counts in bronchi and bronchioles became normal. In alveolar areas, the counts were very high 8 hours after the beginning of exposure. After this initial peak, the labeling counts fluctuated to show three additional peaks of increased labeling at 40 hours of exposure, at 24 hours of recovery, and at 72 hours of recovery. The counting procedures for three alveolar areas (subpleural, peribronchiolar, and midzonal) showed no significant differences. The significance of these observations is as follows: (1) inhalation of very dilute cigarette smoke produces a marked effect on pulmonary cellular kinetics; (2) different cell populations of the lung respond in a different manner; and (3) the response to cigarette smoke, a mixture of a large number of chemical carcinogens, was significantly different from that of the response to high oxygen, a noncarcinogenic agent. These observations substantiate the importance of including measures of cell kinetics in a wide variety of experimental studies. For studies in which effects on cell proliferation to be enhanced or inhibited, sequence emulsion autoradiography with H^3-Thymidine are uniquely important.

Publications: None

EC-00338-01 (UI-01025-01)

FORMATION OF NONVOLATILE PARTICULATES FROM ORGANIC VAPORS

CLYDE ORR, JR.
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

Objectives: To study droplets and particles formed from organic vapors on the surfaces of crystals. Basically, the aim is to study the droplets and particles originally observed by Professor Pfefferkorn of Germany to form on the surfaces of crystals in the presence of certain types of radiation. It is proposed to first determine the

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conditions of formation of droplets with a variety of organic vapors and then to attempt to study the chemical composition of the droplets formed. So far, this has not been done by anyone. Techniques to be used for the analysis will be a scanning electron microscope as well as a variety of microchemical techniques.

Significant Results: The technical literature describes the appearance of very small particulates on metal oxide whiskers and solid surfaces exposed to laboratory air in the presence of X-rays and ultraviolet radiation. This investigation has established that particulates do form in low concentrations of organic vapor in air when exposed to X-rays but that the metal oxides serve only as convenient deposition sites. The metal oxides have no part in the formation.

Particulates formed from benzene and other hydrocarbons appear yellow when collected as a thin layer on a glass plate but the color changes to amber and brown as thicker layers develop. The particulates are generally less than one-half micron in diameter. There was apparently no evaporation or reduction in size of the particulates when subjected to a high vacuum at room temperature for two days. A small reduction in size was detected after heating at 250°C for four hours and substantial size reduction was attained after 30 hours.

The rate of production of particulates depends on vapor concentration, the humidity of the air, and the intensity of the X-rays. Particulates are formed, nevertheless, when both vapor concentration and humidity are low. Particulates have been produced, for example, with so-called zero air -- hydrocarbon content less than 2 parts per million -- and commercial-grade dry nitrogen.

Tests are presently in progress utilizing ultraviolet light instead of X-rays; the chemical composition of the particulates is being investigated; and the relationship of vapor composition, humidity, radiation intensity, and other factors are being studied.

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EC-00338-01 (Continued)

The normal atmosphere of the earth contains various organic vapors, and it is exposed to both X-ray and ultraviolet radiation from the sun and other celestial bodies. From the experiments described above, it would appear that particulate matter is being formed there and that its production is a factor in air pollution. This investigation is seeking to discover some of the significance of this source of air pollution.

Publications: None

EC-00339-01
(UI-01026-01)

MEASURING CARBON MONOXIDE EFFECT WITH TRACE METALS

RONALD L. COLEMAN
UNIVERSITY OF OKLAHOMA MEDICAL CENTER
OKLAHOMA CITY, OKLAHOMA

Objectives: This study will test the hypothesis that carbon monoxide modifies enzyme metabolism by causing trace metal translocations, and that these can be observed prior to clinical manifestations. The study seeks, then, to evaluate the trace metal technique in the detection and analysis of the effect of chronic exposure to carbon monoxide. Metals to be measured initially are copper, cobalt, zinc, iron and magnesium in brain, heart, liver, lungs, kidneys, spleen, blood serum, erythrocytes, and urine of rats following exposures to carbon monoxide levels of 25, 50, 100 and 200 parts per million. Exposures will last for fifteen weeks, five days per week, six hours per day. If time permits, a single metal and/or organ will be selected for a more in-depth study.

A total of forty albino rats will be exposed to each carbon monoxide concentration and carbon monixide will be analyzed using an infra-red analyzer. Unexposed animals will serve as controls. At the end of the third week and at each three-week interval thereafter approximately 8 exposed and 8 control animals will be sacrificed and subjected to analysis for trace metals using atomic absorption spectroscopy

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EC-00339-01 (Continued)

techniques previously developed in this laboratory. Metals will be measured in terms of total organ content and on the basis of weight to weight of ashed organ. Statistical evaluation will be done using analysis of variance.

Significant Results: This is a new project therefore significant progress is not available.

Publications: None

EC-00341-01 (UI-01064-01)

THE SLEEP-WAKING CYCLE AND ITS NEURO-ENDOCRINE CORRELATES

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MONTEFIORE HOSPITAL AND MEDICAL CENTER
BRONX, NEW YORK

Objectives: The objective of this project is to examine the relationships, if any, of the sleep-waking cycle and the circadian rhythm of various hormones. In particular interest in REM sleep periods as possible indicators of intense neuroendocrine activation. A close look will be taken at the plasma steroid levels as expressions of ACTH release. Attention will be devoted to urinary osmolality for evidence of ADH release while checking for GFR changes with creatinine. Plans are to include insulin and growth hormones among those to be investigated. Experimental manipulations will include shifting the sleep-waking cycle 180 degrees out of phase and manipulating the amount of REM sleep. A look will be taken for reverse phenomena, i.e., the effects of hormones such as ADH, ACTH and also hypo- and hypertonic saline, etc. on sleep. Many of the studies will be carried out in normal volunteers. A parallel set of experiments using monkeys, with implanted venous channulas and electrodes, is planned also.

Significant Results: The new information obtained from research is as follows. It is now clear from findings that cortisol, an important hormone necessary for the

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EC-00341-01 (Continued)

survival of man, is released in short, intermittent secretory bursts during sleep, in particular during the latter half of the sleep period. In addition, it has been recently confirmed that the measurement of the specific activity of cortisol, using a precise radioactive tracer, indicates that these rapid changes in cortisol are due to new hormones being released from the adrenal cortex and therefore very probably due to the stimulation of ACTH coming from the pituitary gland. In addition to the above finding during sleep there is recent evidence that the hormone is secreted in an intermittent manner during the non-sleep period of the day as well. When the normal young adult subjects were subjected to an acute 180° phase shift of their sleep-wake cycle it was clear that the rate of change of phase shift of the hormone secretion cycle was quite slow. After 2 weeks the subject's sleep-waking cycle was still dissociated from his circadian adrenal cycle. This dissociation was also present when body temperature was measured but was less evident when other substances, such as urinary sodium and creatinine and potassium and urine volume were studied. These latter findings emphasized the importance of recognizing the significant degree of metabolic and physiologic dissociation which can occur when sleep-wake cycles are acutely shifted in man.

When growth hormone was measured recent findings were confirmed that it is released during the early portion of the sleep period. In contradistinction to the slow time course shift of cortisol, the growth hormone shifted very rapidly indeed and appeared to be tied very closely to the sleep pattern. Therefore, these two hypothalamic pituitary hormone systems responded quite differently to the 180° sleep-wake cycle shift.

It is also apparent from studies of the total production rate of adrenal cortical hormone, that the adrenals were secreting at the most only about 6 hours in a day and were quiescent for the remaining 18 hours. In addition, it is also apparent that most of the hormone was secreted during a short period of time during the latter half of the night's sleep period and that approximately 2/3 to 3/4 of the total 24 hour hormone secretion occurred during that time in normal adults.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00341-01 (Continued)

Recently extended was the sleep-wake cycle shift period to a 9-week study period. The results indicate that it was possible to invert the temperature cycle during the 2nd and 3rd week following acute sleep-waking inversion. However, when the subject was reinverted back to his normal nocturnal sleep time a rapid reinversion of the temperature cycle occurred. This finding is important in that it indicates that although there is apparent cycle inversion by graphic definition this could be readily reversed back over a much shorter time period after the return to nocturnal sleep. This again supports the concept that certain fundamental biological rhythms are very strongly established according to a specific time cycle distribution and that these patterns are quite resistant to shift.

Following the reversal of the sleep-wake cycle the sleep patterns of the subjects were also significantly altered. These alterations generally persisted for the 2-week period after reversal. It was found that a significant decrease in time from sleep onset to the first rapid eye movement period was present although in spite of this tendency for rapid eye movement sleep to occur earlier in the sleep period the Stage 3-4 stages of sleep also occurred in the first 3 hours of the sleep period. The number of interruptions and interrupted eye movement epochs were also significantly increased and the subjects frequently awoke toward the end of the sleep periods following reversal, thus indicating the significant degree of disruption and alteration of sleep following acute sleep-wake inversion.

A further study carried out, although not directly in line with the above findings, but nevertheless of clinical significance, was a study done in collaboration with Dr. James Dexter and Dr. Arnold Friedman. In this study an examination was made of the relationship of nocturnal migraine headaches to sleep stages. We found that the occurrence of nocturnal migraine and cluster headache attacks was temporally closely related to the rapid eye movement sleep stage. This is the first evidence that relates migraine headache attacks to a specific physiologic state.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00394-03 (UI-00468-03)	EXPERIMENTAL PATHOLOGY OF AIR POLLUTION	HOLLIS G. BOREN UNIVERSITY OF COLORADO DENVER, COLORADO

Objectives: This project involves the construction of exposure chambers which allow 99% concentrations of gases and particulates to be achieved in 30 seconds. Hamsters have had inhalation exposure to activated charcoal, titanium dioxide, nitrogen dioxide, and cigarette smoke. Following an acute, precisely-timed exposure, series of animals were killed at increasing intervals following the completion of the exposure. Static deflation pressure volume relations of lung were measured to give one indication of altered surface activity of lung. Tissues were then fixed by perfusion with isotonic neutral buffered glutaraldehyde for light microscopy, giving anatomical observations on the same lungs upon which pressure volume relations had been measured. Deposition of particles at the site of change of direction of inflowing air was confirmed. Very early at the alveolar level, carbon particles were transferred to and phagocytized by Type B cells to a much greater extent than by alveolar macrophages. The alveolar accumulations of cells with greater particle burdens and changes in cell proliferation and migration in conducting airways after inhalation of cigarette smoke require additional techniques. To this end a method of labeling lung cells with tritiated thymidine followed by emulsion autoradiography has been standardized and has been added to the above methods.

Significant Results: Pulmonary cellular kinetics have not been considered in most studies of the lung to date. Colchicine blockade of mitosis is an insensitive method and it had been used only in normal animals. Autoradiography using the stripping film technique did not allow cellular detail to be seen and this technique also had been used only in normal animals. The techniques required for emulsion autoradiography with H^3-Thymidine were established in our laboratory. The factors of dose, time of sacrifice, and specificity of labeling were evaluated and a standard procedure was developed. Normal values of labeling of bronchi, bronchioles, and alveolar Type B cells were determined for male hamsters. These studies provided a

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EC-00394-03 (Continued)

background to evaluate the effects of inhalational exposure to high and to low concentrations of oxygen. Exposure to 555 mm/Hg partial pressure of oxygen for 48 hours resulted in a marked increase in the degree of labeling of cells of the bronchi, bronchioles, and Type B cells. Exposure to 85 mm/Hg partial pressure of oxygen for 48 hours gave no change in normal labeling values. In the high oxygen experiment, there was a lag of 24 hours before increased labeling was observed. Increased labeling then persisted for 48 hours after the end of exposure to high oxygen concentrations. In general, these changes occurred in the absence of alterations of pressure volume relations of lung, or the development of pulmonary edema. Cells of the glomerulus of kidney showed an increase of labeling but there was no change of the labeling of liver, esophagus or epidermis of ear. The significance of these observations is: (1) the presence of a lag period and the persistence of increased labeling into recovery determines the design of inhalational exposure experiments; (2) the cellular response to high oxygen concentration indicates that a similar response to oxidant gases may be anticipated; (3) that emulsion autoradiography is a sensitive method of detecting response of lung to injury; and (4) that alterations in organ systems other than lung following inhalation exposure may be detected by autoradiography with H^3-Thymidine.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00016-09 (UI-01030-09)	ENVIRONMENTAL HEALTH	DADE W. MOELLER HARVARD UNIVERSITY BOSTON, MASSACHUSETTS

Objectives: The primary objective of this training grant is to provide graduate research training in specialized areas of environmental health for candidates desiring to become research workers, specialists and teachers. Emphasis is placed on students majoring in the engineering or physical sciences such as physics and chemistry. Graduate training will take place in relation to ongoing research on such topics as the sampling and analysis of air pollutants, procedures to assess human exposure, industrial ventilation, heat stress control, and the evaluation of human factors.

EC-00018-07 (UI-01038-07)	OCCUPATIONAL HEALTH	FREDERICK H. SHILLITO OHIO STATE UNIVERSITY COLUMBUS, OHIO

Objectives: 1. This is a program of basic scientific training and research techniques applied to a background of occupational medicine.

2. The objective of this program is to prepare physicians to serve as effective and well informed practitioners, investigators, teachers, or administrators in the field of either Aerospace or Occupational Medicine.

3. These men are trained not only to initiate and carry out individual research projects but also to work in integrated interdisciplinary teams with engineers, physicists, mathematicians and chemists which is essential in dealing with the solution to complex environmental hazard problems.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00020-04 (UI-01045-04)	ENVIRONMENTAL HEALTH	BERNARD D. TEBBENS UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

Objectives: To train graduates for the M.S. and Ph.D. degrees in Environmental Health Sciences. Research with a thesis is part of each degree. The areas of specific interest include Environmental Biology, Industrial Hygiene and Air Resources.

The high caliber of the student accepted into and continued in the programs is assured by the rigid entrance and performance requirements of our Environmental Health Sciences group and of the Graduate Division of the University. Student research is continuously supervised and directed by qualified faculty members.

EC-00024-03 (UI-01050-03)	BIOENVIRONMENTAL ENGINEERING	RALPH G. NEVINS KANSAS STATE UNIVERSITY MANHATTAN, KANSAS

Objectives: The purpose of this proposal is to establish a program leading to the Ph.D. degree with a major in Bioenvironmental Engineering. The program is administered by the Department of Mechanical Engineering, but is carried on as an interdisciplinary effort of the Physiology Department, Statistics Department and the staff of the Institute for Environmental Research. The philosophy under which this program is administered is to provide training in engineering and then to supplement that information with training in the life sciences.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
FC-00028-02 (UI-01061-02)	INDUSTRIAL HYGIENE	JAMES O. PIERCE UNIVERSITY OF CINCINNATI CINCINNATI, OHIO

Objectives: This proposal is for the purpose of supporting existing Master's and Ph.D. programs in Industrial Hygiene and also contributes indirectly toward support of graduate students enrolled in related programs of study such as Air Pollution, Toxicology, Occupational Medicine and Environmental Sciences. This graduate training program in Industrial Hygiene is distinct from other training programs within the Department and is designed to be a broad approach at the Master's level so that students from various backgrounds can be accommodated, but with specialization in related research areas at the doctoral level.

EC-00031-02 (UI-01065-02)	ENVIRONMENTAL PHYSIOLOGY	GEORGE C. WEST UNIVERSITY OF ALASKA COLLEGE, ALASKA

Objectives: The proposed program is designed to train scholars and researchers in the field of environmental physiology with emphasis on the arctic and subarctic. In addition to formal course work as available, structure seminars will be offered on specialized topics in physiology each semester, a comprehensive research preceptorship program, and a technical seminar in the Institute. Students are expected to have achieved the M.S. degree or its equivalent before entry. Normally students will spend three years and obtain the Ph.D. degree after completion of course work background, language and qualifying examinations, and an acceptable dissertation followed by a final examination.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00036-08 (UI-01035-08)	OCCUPATIONAL FACTORS IN HEALTH	CARL A. NAU UNIVERSITY OF OKLAHOMA OKLAHOMA CITY, OKLAHOMA

Objectives: Graduate students are selected from a list of qualified applicants. In consultation with the student, an advisory committee of the graduate faculty "custom-builds" a program using all the applicable facilities and skills of the University on an interdisciplinary basis. This program is planned to qualify the student for a Master (MPH or MS) and/or Doctor's (DPH or Ph.D.) degree as offered through the graduate college. Opportunity for original and acceptable research is provided in the area of the students interest and competency. Basic courses in Epidemiology, Biostatistics and Public Health Administration are required. Opportunity for field experience is provided.

EC-00037-06 (UI-01042-06)	INDUSTRIAL HEALTH	HAROLD J. MAGNUSON UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN

Objectives: The program is designed to develop scientists and teachers who will add to the national resource inventory required by environmental health responsibilities. Because an important source of environmental contamination arises from the products and effluents of technology based industry, there is a need for scientists capable of quantitatively evaluating the presence and health effects of physical and chemical agents arising from industrial sources. In view of the competence of this Department in the area of Occupational Health, and its broad-based experience in dealing with the health resultants of industrial activity, it will act as the point of departure and foundation for research training. In addition, because of on-going research programs utilizing biochemical, physical and physiological approaches to broad occupational health problems, the student will have the opportunity to utilize these activities for doctoral research experience.

BUREAU OF RADIOLOGICAL HEALTH

Functional Statement

Carries out programs designed to reduce the exposure of man to hazardous ionizing and non-ionizing radiation. Develops criteria and recommends standards for safe limits of radiation exposure. Develops methodology for controlling radiation exposures. Plans and conducts research on the health effects of radiation exposure. Provides technical assistance and training to agencies having a radiological health program. Conducts an electronic product radiation control program to protect the public health and safety, including the development and administration of performance standards to control the emission of radiation from electronic products and the undertaking by public and private organizations of research and investigation into the effects and control of such radiation emissions.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00009-04 (RH-00450-04)	TRANSFER MECHANISMS IN IRRADIATED BIOLOGICAL SYSTEMS	HAROLD C. BOX HEALTH RESEARCH, INC. NEW YORK STATE DEPARTMENT OF HEALTH ALBANY, NEW YORK

Objectives: To improve understanding of the chemical changes caused by ionizing radiation. Molecular damage produced by ionizing radiation is often transferred from one part of a molecule to another part, or even from one molecule to another molecule. In this investigation, such transfers of damage are being studied in a variety of biological molecules. A form of spectroscopy known as magnetic resonance spectroscopy is used to observe the transfer processes.

Significant Results: The outstanding accomplishment during the past year was the complete analysis of the radicals produced in ice by ionizing radiation. This analysis was accomplished by a combination of magnetic resonance techniques.

Ever since it was discovered that electron spin resonance spectroscopy is an excellent tool for studying radiation damage, researchers have tried to determine the effect of radiation on ice. Water, of course, is a principal ingredient of living things and the radiation chemistry of water is fundamental to radiation biology. In magnetic resonance studies of radiation damage to water, ice is used in order to stabilize the reactive radiation products. However, the complexity and the disorder in the ice structure defeated all attempts to analyze definitively the effects of radiation on ice.

During recent years a combination form of magnetic resonance spectroscopy known as ENDOR (electron and nuclear double resonance spectroscopy) was developed at this laboratory for use in radiation studies. With ENDOR it proved possible to completely analyze the absorption spectrum of irradiated single crystals of ice.

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EC-00009-04 (Continued)

The absorption at 77°K was shown to be due to the superposition of 21 different OH radical absorptions. These OH radicals occur in 3 different environments. Each environment is reproduced in space in a number of different orientations. One environment occurs in 12 different orientations, another in 6 orientations and the remaining one in 3 orientations.

The work is being extended to determine the effect of radiation on solute molecules in aqueous solutions.

Publications: Whelan, D. J., "ENDOR Study of Irradiated L-Glutamic Acid Deuterochloride," J. Chem. Phy., 49, 4734 (1968).

Box, H., Budzinski, E. E., and Gorman, T., "Paramagnetic Study of Ionized Thiourea Derivatives," J. Chem. Phy., 48, 1748 (1968).

EC-00029-04 (RH-00416-04)

RADIATION DOSE AND DIAGNOSTIC ISOTOPE PROCEDURES

EDWARD M. SMITH
SOCIETY OF NUCLEAR MEDICINE
NEW YORK, NEW YORK

Objectives: The primary objective of the Medical Internal Radiation Dose Committee of the Society of Nuclear Medicine is to provide the best possible estimate of the absorbed dose to patients resulting from the diagnostic or therapeutic use of internally administered radiopharmaceuticals. In order to achieve this objective the Committee collects, analyzes, and publishes in convenient form necessary data on the distribution of radiopharmaceuticals; physical and nuclear decay scheme data for relevant radionuclides; and physical, chemical, and biochemical properties which may affect the biological behavior of radiopharmaceuticals. The work of the MIRD Committee is expected to continue as long as new diagnostic and therapeutic radiopharmaceuticals are being developed.

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EC-00029-04 (Continued)

Significant Results: These are best represented by the published output below and include tabulations of radionuclide parameters and gamma and X-ray energy absorbtion fractions in tissue.

Publications: Official publication of the Society of Nuclear Medicine, Inc., "MIRD--Journal of Nuclear Medicine," Supplement No. 2, Pamphlet 4 and Supplement No. 3, Pamphlet 5.

EC-00064-08 (RH-00005-08)

RADIATION EFFECTS ON FORMATION OF PROTEIN AGGREGATES

HERMAN R. HAYMOND
UNIVERSITY OF SOUTHERN CALIFORNIA
LOS ANGELES, CALIFORNIA

Objectives: This investigation is concerned with elucidating the mechanism by which ionizing radiation interferes with interactions between proteins in aqueous solution, particularly interactions envolving weak bonds in the formation of protein aggregates. Current work is related to the effects of radiation on interactions between antigens and antibodies.

Significant Results: Recent work has been directed toward investigation of the properties of the products of irradiation of rabbit and human immunoglobulins. The methods used have included Sephadex gel chromatography, discontinuous acrylamide gel electrophoresis, electrophoresis on cellulose acetate membranes, and ultracentrifugation. Irradiation of either rabbit or human IgG fractions results in the formation of products of both higher and lower molecular weights (indicated by ultracentrifuge studies) and of higher and lower electrophoretic mobilities in acrylamide disc electrophoresis but only lower electrophoretic mobility in cellulose acetate membranes. There is a continuous spectrum, without distinctive molecular weights or electrophoretic mobilities, in the products. Human IgG is more sensitive than rabbit IgG to the formation of postirradiation aggregates.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00065-08 (RH-00008-08)	STUDIES OF RADIATION DAMAGE TO BIOLOGICAL MATERIALS	ROY S. ANDERSON CLARK UNIVERSITY WORCESTER, MASSACHUSETTS

Objectives: Molecules which have been damaged by high energy radiation are generally weakly magnetic. This magnetism is detectable by a highly sensitive radio spectroscopic technique known as Electron Spin Resonance. In addition to detecting the presence of magnetic, radiation-damaged molecules, Electron Spin Resonance spectroscopy can also reveal details such as the location within the molecule at which radiation damage occurred. Single crystals of biological materials are grown and exposed to ultraviolet, X-, gamma, and neutron radiation. The small concentrations of damaged molecules (between 0.1 and 5 percent), which are stably trapped in the crystal lattice, are investigated by Electron Spin Resonance spectroscopy.

Significant Results: Single crystals of biological compounds have been subjected to various radiations, such as gamma-rays, X-rays, ultraviolet rays and various particles, such as thermal neutrons and thermal hydrogen atoms. Damage to the crystal is being studied using the highly sensitive Electron Spin Resonance technique. Experiments have shown that damage to biological materials most frequently results from the breaking of the chemical bonds between the constituent atoms of the molecules. Furthermore, there is a distinct ordering in the radiation sensitivity of the various chemical bonds: carbon-sulphur bonds appear to be the most susceptible to radiation, followed by carbon-nitrogen bonds, carbon-hydrogen bonds and carbon-oxygen bonds, in descending order.

Of the various types of radiation employed, gamma and X-radiations are the most damaging. Thermal neutrons produce only a slight effect and ultraviolet radiation has been similarly ineffective. Of special interest have been observations that hydrogen atoms readily attach themselves to unsaturated organic compounds to produce essentially new compounds.

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EC-00065-08 (Continued)

From experiments it is possible to infer the relative tolerance to damaging radiation. It is also possible to infer how radiation affects the functioning of living systems and to determine permissible levels of exposure. Studies on the decay of damaged molecules show how living systems recover from radiation damage. Finally, the results of these experiments may be used to identify specific radiation protective agents which guard against or assist in recovery from radiation damage.

Publications: Shrivastava, K. N. and Anderson, R. S., "Electron Spin Resonance Study of γ-Irradiated Single Crystals of Semicarbazide Hydrochlorids," J. Chem. Phys., 48 (1968)

EC-00066-14 (RH-00021-14)

THE EFFECTS OF X-IRRADIATION ON THE SMALL INTESTINE

JAMES W. OSBORNE
UNIVERSITY OF IOWA
IOWA CITY, IOWA

Objectives: The objective of this project is to learn more about the consequence of exposing the small intestine of rats to X-irradiation, Also to determine the sequence and quality of radiation-induced changes which precede the early loss of intestinal mucosa and in many cases the later appearance of intestinal tumors.

Significant Results: The study of radiation-induced intestinal carcinoma in rats has yielded the most significant results to date. The basic procedure involves delivering 2000 R of X-radiation to the temporarily exteriorized ileum and jejunum made ischemic by clamping the superior mesenteric artery and vein during 70 percent of the radiation exposure period. Holtzman, Simonsen, and August rats have been used. Intestinal carcinomata developed with high frequency in 50 percent of the Holtzman rats treated and were often seen in the 5-10 month postirradiation interval. Simonsen and August rats developed fewer intestinal tumors, 10 and 15 percent, respectively. The tumors were noted later (12-18 months) than in Holtzman rats and gut lesions besides carcinoma were seen, viz., angiosarcoma, fibrosarcoma, and osteogenic sarcoma. The reasons for the differences are being sought.

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EC-00066-13 (Continued)

In Holtzman rats, resection of the tumor and restoration of intestinal continuity with an end-to-end anastomosis is followed by the development of additional tumors at other sites in the gut, and at a much faster rate than ever shown by the original lesion. This response presents an excellent opportunity to study tumor histogenesis. Accordingly, experiments to study the intestine which remains after resection of the primary tumor are underway.

The low incidence and late appearance of radiation-induced carcinoma in Simonsen and August rats plus the occurrence of other intestinal lesions is of great interest because the response is in marked contrast to that of the Holtzman strain. Therefore, some opportunities for establishing cause and effect exist.

Temporarily exteriorized segments (2.5 cm or 7.5 cm) of rat ileum were X-irradiated with 3000 R or 5000 R. Animals died between 10 and 200 days. A lesion characterized by extensive serosal fibrosis was produced and death of the animals was due to obstruction. There were no carcinomas or other tumors. Since humans accidently and sometimes necessarily have segments of intestine irradiated during the course of therapy, it seems desirable to use additional combinations of segment length and X-ray exposure to determine which produce only ulceration, only tumors, or damage which is almost entirely repaired after considerable time.

Publications: Sigdestad, C. P., Osborne, J. W., Levine, D. L., "The Influence of Prior Intestinal Resection on Survival Time of Intestine-Irradiated Rats," Int. J. Radiat. Biol., 15, (1968)

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00067-07 (RH-00030-07)	ENVIRONMENTAL EFFECTS ON THE CONTENT OF ^{137}Cs IN MILK	ROBERT C. PENDLETON UNIVERSITY OF UTAH SALT LAKE CITY, UTAH

Objectives: This study is designed to determine the environmental factors which are responsible for the observed seasonal and geographic differences in content of ^{137}Cs and ^{90}Sr in milk, animal fodders, and humans, and to determine the range of these variations in environments represented by selected dairy farms of Utah. Field studies are planned to test the validity and importance of factors affecting fallout accumulation which had been identified in the laboratory. Hopefully the study will determine how farming practices can be modified to lessen transfers of fallout to foods and man.

Significant Results: Extensive measurements of $^{137}Cs/K$ ratios in humans and milk have been used to develop a method for estimating human body burdens using only the $^{137}Cs/K$ ratios in milk or in other staple foods for populations in which milk products are unimportant in the diet. This method has potential value for hazards evaluation, and can be used in the absence of expensive whole-body counting facilities.

A method for removal of radionuclides from natural waters has been perfected which is highly accurate, sufficiently portable for use in the field, and inexpensive.

Leached from soil surfaces and decaying vegetation, ^{137}Cs moves via watercourses in ionic form, and fixed on silts and organic matter. Transport of this nuclide into "hot spot" fields yields deposition levels in excess of 0.58 Ci/mile square. Gradual release of ^{137}Cs from soils and vegetation (mosses in watercourses range from 5 to 280 nCi ^{137}Cs/kg wet weight) leads to constant removal from watersheds with contamination levels progressively increasing as the stream descends to the valleys. Under present fallout rates, some "hot spot" fields lose more than 1μCi ^{137}Cs/day. The lost material is redeposited at lower altitudes, and the high deposition on surface soils (25 nCi/kg in the top 1 cm on some farms) is a result of stream transport.

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EC-00067-07 (Continued)

During high fallout, soil factors have little effect on accumulation of ^{90}Sr and ^{137}Cs in milk relative to other factors of the environment. Studies have shown that by manipulating farming practices, levels of ^{90}Sr and ^{137}Cs can be reduced. The required changes in farming practices are all standard procedures of good tilth, and only feeding changes involve potential economic stress.

Publications: Lloyd, R. D., Zundel, W. S., Mays, C. W., Wagner, W. W., Pendleton, R. C., Aamodt, R. L., Tyler, F. H., "Short Cesium Half-Times in Patients with Muscular Cystrophy," Nature, 220, 1029 (1968).

Zundel, W. S., Tyler, F. H., Mays, C. W., Lloyd, R. D., Wagner, W. W., Pendleton, R. C., "Short Half-Times of Cesium-137 in Pregnant Women," Nature, 221, (1969).

EC-00068-08 (RH-00039-08)

FOLLOW-UP STUDY OF PATIENTS WHO RECEIVED THOROTRAST AND OF CONTROL GROUP

JORGE da SILVA HORTA
UNIVERSITY OF LISBON
LISBON, PORTUGAL

Objectives: To ascertain the possible pathological consequences of a radioactive material ("Thorotrast" - a thorium dioxide colloidal suspension) used for radiological purposes in humans. Since this material is retained practically indefinitely in the body, the Thorostat population constitutes an invaluable source of material for study of the effects of long-term *in vivo* radiation in man.

Significant Results: The most important clinical consequences ascertained were malignant tumors of the reticulo-endothelial system, of the liver, acute leukemia and other fatal blood dyscrasias (such as aplastic anemia). Additionally were found a general increase of malignant tumors (especially of lung cancer), liver fibrosis (clinically similar to liver cirrhosis) and more than 100 local granulomata at the place where the drug was extravasated into the perivascular tissues (directly causing death in 11 cases of cervical granulomata). A statistical analysis has shown that

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EC-00068-08 (Continued)

the observed frequencies of the causes of death due to these consequences were significantly above the expected frequencies.

In the opinion of the investigators these results were due to the radioactivity of the contrast drug. Besides correlation studies between injected dose and "consequences," studies have been made on the measuring of total body burden and are being made on the counting of chromosome aberrations, with the intention of obtaining a more appropriate dose relationship.

Since 1966 a group of 1850 control cases, constituted of patients injected with non-radioactive contrast drug for reasons similar to the ones of the "Thorotrast" cases, have been assembled, looked for, and when traced, followed up.

Publications: No additional publications.

EC-00069-08 (RH-00042-08)

COMPOUNDS TO PROMOTE EXCRETION OF RADIOISOTOPES

WILLIAM H. STRAIN
UNIVERSITY OF ROCHESTER
ROCHESTER, NEW YORK

Objectives: Compounds are being developed to promote the excretion of radioisotopes. These preparations will find application in reducing the danger from radioactivity received by persons exposed to radionuclides. Thus, the hazards from nuclear accidents and bombs will be reduced, and long-lived radioisotopes may be used more safely for diagnosis and therapy in medicine. Organic complexes of a variety of elements are being synthesized and their properties studied.

Significant Results: A variety of compounds have been developed to promote the excretion of radioisotopes from the body. The compounds include preparations to remove radioactive cobalt, iron, manganese, mercury, and zinc; also compounds have

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00069-08 (Continued)

been found to remove radionuclides of cesium, cobalt, and plutonium. All these preparations are still very much in the investigative stage as far as humans are concerned, but the animal work seems nearly complete.

Another important discovery made earlier is being evaluated. It was found that radio-zinc was accumulated in the arteries of experimental animals. The accumulation was especially high if the animals were zinc deficient. The retention suggested that zinc is important to the maintenance and repair of blood vessels. Since zinc deficiency has also been found to be common in patients with atherosclerosis, an inexpensive therapy has been introduced for the treatment of inoperable vascular disease. This therapy consists of oral medication of a zinc deficient patient with zinc sulfate capsules, 220 mg t.i.d. The results have been gratifying in patients suffering from intermittent claudication, but it will be some years before the merits of the therapy can be evaluated. It is suspected that zinc therapy promotes repair of the arteries just as it has been found to accelerate healing of burns and wounds. Thus, the medication introduced for external healing may have great utility for internal repair.

Publications: Strain, W. H., Rob, C. G., Pories, W. J., Terry, R. A., Childers, R. C., Hennessen, J. A., Thompson, M. F. Jr., and Graber, F. M., "Activation Analysis of a Human Abdominal Aneurysm," Trans. Am. Nuc. Soc. 11, 477, (1968).

Strain, W. H., Pories, W. J., Peer, R. M., Childers, R. C., Worland, R. L., Zaresky, S. A., and Rob, C. G., "Radioisotope Accumulation in Vascular Wounds As a Measure of Arterial Repair," Trans. Am. Nuc. Soc., 11,475, (1968).

Strain, W. H., Pories, W. J., Dattilo, E., Peer, R. M., and Zaresky, S. A., "Influence of Age and Sex on Absorption and Retention of Radioisotopes," Trans. Am. Nuc. Soc. 11, 476, (1968).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00069-08 (Continued)

Strain, W. H., Rob, C. G., Pories, W. J., Hennessen, J. A., and Montoya, J., "Zinc Binding Capacity and Zinc Levels of Serum," J. Nuc. Med., 9, 352, (1968).

Strain, W. H., Pories, W. J., Zaresky, S. A., Dattilo, D., "Health Hazards from ^{65}Zn Pollution," Trans. Am. Nuc. Soc., 11, 60, (1968).

Strain, W. H., Peer, R. M., Thomas, M. R., Gas, A. P., and Pories, W. J., "Promotion of ^{203}Hg-Chlormerodrin Excretion by Cold Chlormerodrin or Mercurhydrin," J. Nuc. Med., 9, 373, (1968).

EC-00070-14 (RH-00065-14)

IONIZING RADIATION BEHAVIORAL DEVELOPMENT AND AGING

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Objectives: To determine the behavioral effects of ionizing radiation administered during the developmental period. The effects of age at the time of exposure as well as dose will be determined. Different types of functions, simple as well as complex, will be investigated. Animals will be studied throughout their lifespan to see whether the effects of irradiation remain constant, or whether they become exacerbated or ameliorated. The latter aspect of the research also should provide data for an analysis of behavioral changes during aging. The interrelationship of the various changes may provide us with a model for a behavioral embryology.

Significant Results: There have been some research reports according to which rats irradiated in utero on day 18 of gestation with 1 R of X-rays showed deficits in conditioning as adults. Since this is by far the smallest quantity of irradiation reported to induce relatively permanent changes, an attempt was made to replicate this work. In a series of experiments with the Kotlyarevsky technique it has not been possible to observe deficits even with doses of 50 R, although animals exposed to 100 R did show changes on some, but not all indexes of conditioning.

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EC-00070-14 (Continued)

In other experiments prenatally irradiated rats (50 to 200 R) were tested in various kinds of aversive conditioning situations. Here, too, no permanent changes could be observed in animals exposed to 50 R, but animals which had received 200 R showed large changes. In addition, there was a relationship between task difficulty and the response observed using drugs affecting the central nervous system. Thus, it is inappropriate to say that prenatal X-irradiation induces deficits in conditioning.

Some preliminary observations have indicated changes in the maternal behavior of irradiated rats and in the behavior of nonirradiated rats toward irradiated pups. Thus some of the previous findings of deviant behavior in adult rats exposed to ionizing radiation during development is associated with some of the changes observed in the mother-pup interaction prior to weaning. However, these changes cannot account for all of the observed deficits in adult rats which had been exposed *in utero*.

Publications: Deagle, J. and Furchtgott, E., "Passive Avoidance in Prenatally X-Irradiated Rats," Dev. Psychobiol., 1, 90, (1968).

Furchtgott, E., Tacker, R. S., and Draper, D. O., "Open-Field Behavior and Heart Rate in Prenatally X-Irradiated Rats," Teratology, 1, (1968).

Furchtgott, E., "Behavioural Effects Produced by Irradiation During the Developmental Period," Am. Zoologist, 7, (1967).

EC-00071-10 (RH-00076-10)

RADIOBIOLOGICAL RESEARCH ON MARINE ORGANISMS

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Objectives: This grant supports a hot lab area, comprised of ten inter-connecting rooms, on the fourth floor of Whitman Laboratory, at the Woods Hole Marine Biological

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EC-00071-10 (Continued)

Laboratory. These rooms, equipped with appropriate counting devices as well as radiation sources, are made available to qualified investigators. The funds also defray the expenses of the radiation safety officer and his assistant.

Significant Results: Since this grant relates to a wide variety of radiobiological experiments it is only possible to indicate results from a few of the many researches that have benefited from this support.

Results of research on mitotic delay in the eggs of the sea urchin Arbacea Punctulata have shown that treatment with high hydrostatic pressure and potential-parthenogenic activating agents leads to a reduction of radiation-induced mitotic delay. It is thought that this delay may be due to either initiation of events which permit the cell to bypass the stages normally delayed by radiation or to stimulation of repair mechanisms.

Studies of the effects of cesium-137 gamma-rays on regeneration in the coelenterate Tubularia has yielded data related to radiation dose response, for regeneration can be increasingly protracted and the process completely inhibited. The lethal dose for the organism is in the range required to deactivate many viruses.

The radiation sensitivity of Sorcoma 180 and Krebs 2 in white albino mice was shown to be markedly increased in mice treated with keto-aldehydes and irradiated with cesium-137 gamma rays.

A wide variety of experiments involved the use of radioactive tracers in studies of fundamental biological mechanisms including nerve conduction, active membrane transport, bioluminescence, differentiation, and bioregulation.

Publications: Not applicable.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00072-10 (RH-00095-10)	INACTIVATION OF ENZYMES BY IONIZING RADIATION	EVELYN S. SLOBODIAN NEW YORK UNIVERSITY MEDICAL CENTER NEW YORK, NEW YORK

Objectives: To inquire into the basic mechanisms of radiation effects by studying the irradiation of ribonuclease, one of the enzymes which may be involved in the control of growth and reproduction. It is hopeful to obtain a sophisticated understanding of how irradiation damages the enzyme molecule, and how such damages correlate with impairment of enzyme function.

Significant Results: Evidence of striking similarities between gamma-irradiated ribonuclease and samples obtained by treatment of this enzyme with chemically produced hydroxyl-radicals (from Ferrous and Peroxide), was revealed in earlier work. Subsequent studies showed that irradiated enzyme was extensively "unfolded," and led to a re-examination of hydroxyl treated enzyme, with a view towards comparing its structure with that of irradiated enzyme. The aim of continued studies was to evaluate hydroxyl treatment as a model of the irradiation effect.

A further similarity was reported between the irradiated and hydroxyl treated ribonuclease: Unlike native enzyme, both types of inactivated samples complexed strongly to ferric and ferrous iron. The iron-protein complexes were isolated from reaction mixtures by gel-chromatography; specific color tests measured ferrous and ferric iron.

Continued studies have demonstrated the accuracy of the iron color tests: When radioactive iron was used in experiments, color estimates of total iron agreed well with values obtained by isotope assay. As much as four atoms of total iron have been found complexed to an inactivated protein; this probably being a minimum value, since the gel is a strong competitor for ferric ions. Irradiated enzymes bind more to added ferric than added ferrous. Color tests show hydroxyl inactivated protein contains

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both ferric and ferrous ions; the proportion of ferrous ions increases markedly with time. Irradiated enzyme-ferric complexes similarly show conversion of ferric to ferrous on standing. Thus, both types of inactivated protein iron complexes behave like redox metal proteins.

Iron complexing to irradiated ribonuclease occurs even weeks post-irradiation, and is obviously related to the permanently unfolded state of the molecule. The same considerations may apply to hydroxyl inactivated enzyme. (Prototypes unfold molecules, such as oxidased ribonuclease and heat-denatured enzyme, did not bind iron. Reduced enzymes reduced ferric ions, but the recovered protein contained only a trival amount of ferrous ions.)

Both irradiated and hydroxyl treated enzyme-iron complexes are isolated in weakly acidic, to, or almost, neutral media, in which the complexes are very stable. In strong acid the complexes are very stable. In strong acid the complexes dissociated to yield iron-free proteins, which can be isolated and studied. This method is being used to purify hydroxyl treated enzymes from complexed iron, (which separates on gel-chromagraphy as an iron-complex), so that the physical-chemical properties of the protein product can be compared with those of irradiated enzyme.

Publications: No additional publications.

EC-00073-09 (RH-00098-09)

ENZYMATIC AND ESR STUDIES OF RADIATION DAMAGE

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Objectives: To increase understanding of how radiation-induced chemical processes occur in cells and how they can be modified. In order to elucidate the fundamental

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EC-00073-09 (Continued)

mechanisms responsible for biological radiation damage and repair, important biomolecules are irradiated, individually and in combination with modifying substances, and the radiation changes are followed with chemical and physical methods. The results are used to interpret experiments carried out on simple biological systems such as bacteria and red blood cells.

Significant Results: Work on the mechanism of transfer of unpaired spins from macromolecules to sulfur compounds has been continued. Recently it was found that in oxidized penicillamine, sulfur resonance can be detected immediately after irradiation at 77°K. By utilizing this observation it was possible to establish that in certain mixtures of macromolecules with penicillamine an extensive transfer of spin occurs already at 77°K. Previous electron spin resonance studies of the indirect effect in frozen aqueous solutions and suspensions have been continued using different charged derivatives of cross-linked dextran. The results shows that the extent of the indirect action is the same for uncharged and negatively charged derivatives, while it is significantly larger for positively charged derivatives. The results indicate that excited water molecules may partly be involved in the indirect action observed at low temperatures in the frozen state.

The X-ray inactivation of an enzyme having two different functions, viz. the threonine-sensitive asparto-kinase homoserine dehydrogenase from E. coli, has been studied. The results indicated that one of the functions was preferentially destroyed. Thus the kinase activity of the enzyme was two to three times as sensitive as the dehydrogenase function. The results suggested that the loss of the kinase function was caused by destruction of sulfhydryl groups involved in the maintenance of the enzyme complex.

The radiation-induced formation of radicals in thymine, an important constituent of DNA, has been further studied. Thymine and some of its derivatives were exposed in a solid state to X-rays, vacuum UV-light and thermal hydrogen and deuterium atoms. In addition to the previously known 5-thymyl radical, two other radicals have been identified. The radicals are the 6-thymyl radicals formed when hydrogen is added

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EC-00073-09 (Continued)

to C5 and a radical in which a hydrogen atom is added to the oxygen bonded to C4. Also, it was established that the formation of the 5-thymyl radical by ionizing radiation takes place via a precursor radical.

Publications: Sanner, T. and Pihl, A., "Significance and Mechanism of the Indirect Effect in Bacterial Cells. The Relative Protective Effect of Added Compounds in Escherichia Coli B, Irradiated in Liquid and in Frozen Suspension," Rad. Res., 37, 216 (1969).

Pihl, A., Henriksen, T. and Sanner, T., "Effect of pH on the Formation and Intermolecular Transfer of Radiation-Induced Unpaired Spins in Frozen Aqueous Mixtures," Rad. Res., 35, 235, (1968).

Copeland, E. S., Sanner, T. and Pihl, A., "Role of Intermolecular Reactions in the Formation of Secondary Radicals in Proteins Irradiated in the Dry State," Rad. Res., 35, 437, (1968).

Sutherland, R. M. and Pihl, A., "Repair of Radiation Damage to Erythrocyte Membranes: The Reduction of Radiation-Induced Disulfide," Rad. Res., 34, 300, (1968).

Henriksen, T., "Effect of Oxygen on Radiation-Induced Free Radicals in Proteins," Rad. Res., 32, (1967).

Copeland, E. S., Sanner, T. and Pihl, A., "Role of Intermolecular Reactions in the Formation of Secondary Radicals in Proteins Irradiated in the Dry State," Rad. Res., 35, 437, (1968).

Sanner, T. and Pihl, A., "Factors Influencing the Transfer of Unpaired Spins Between Different Solutes in Frozen Aqueous Solutions," Israel J. Chem. 6, 143, (1968).

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EC-00073-09 (Continued)

Sanner, T. and Pihl, A., "Identification of the Water Radicals Involved in X-ray Inactivation of Enzymes in Solution and Determination of Their Rate of Interaction with the Enzyme," Biochem. et Biophys. Act., 146, 298 (1967).

Pihl, A., Henriksen, T., and Sanner, T., "Effect of pH on the Formation and Intermolecular Transfer of Radiation-Induced Unpaired Spins in Frozen Aqueous Mixtures," Rad. Res., 35, 235, (1968).

Sutherland, R. M. and Pihl, A., "Repair of Radiation Damage to Erythrocyte Membranes: The Reduction of Radiation - Induced Disulfide Groups," Rad. Res., 34, (1968).

Henriksen, T. and Sanner, T., "Free Radicals and Their Interactions in Solid Molecular Mixtures," Rad. Res., 32, (1967).

Damjanovich, S., Sanner, T. and Pihl, A., "The Role of the Allosteric Sites in the X-Ray Inactivation of Phosphorylase b," European J. Biochem, 1, 347 (1967).

EC-00074-08 (RH-00099-08)

RBE OF MONOENERGETIC NEUTRONS

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Objectives: To make an evaluation of the relative biological effectiveness (RBE) of neutrons as a function of the energy with close correlation between the physical pattern of energy deposition and the resultant biological effect. A resultant long term objective is an inquiry into the basic modes of action of radiation on the cell with particular emphasis on the effects of irradiation at low levels.

Significant Results: Important developments in research include studies of the effect of neutrons on the lens of the mouse eye where significant opacification has been produced by doses as low as 100 millirads.

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EC-00074-08 (Continued)

Another series of experiments has been concerned with mutations induced in Tradescantia where it was found that neutrons produced a variety of mutations with very high efficiency, including some types seen very rarely with X-rays (RBE values of 100 and more).

An important recent development has been the successful generation of neutrons in the energy band between 0 and 80 kilovolts. As expected, this radiation has a very much lower RBE. However, there are also initial indications that the ratio of mutations to cell killing is markedly higher for this radiation. If these results should be confirmed, these neutrons should be particularly effective mutagens.

Publications: Bateman, J. L., "A Relation of Irradiation Dose-Rate Effects in Mammals and in Mammalian Cells," Brookhaven National Laboratory Report No. 12581.

Rossi, H. H., "Role of Associated Absorption Events in Lenticular Radiation Injury," Panel Report, Int. Atomic Energy Agency, Vienna. (1968).

Bateman, J. L., Rossi, H., "A Relation of Irradiation Dose-Rate Effects in Mammals and in Mammalian Cells," Proceedings of a Symposium on Dose Rate in Mammalian Radiation Biology, April 29, 1968.

Bateman, J. L., Johnson, H. A., Bond, V. P., and Rossi, H. H., "The Dependence of RBE on the Energy of Fast Neutrons for Spermatogonia Depletion in Mice," Rad. Res., 35, 86 (1968).

EC-00075-05 (RH-00140-05)

PROTECTION AGAINST RADIATION DAMAGE TO CHROMOSOMES

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DeKALB, ILLINOIS

Objectives: The purpose of the research grant is to obtain information about chemical substances that may protect chromosomes from radiation injury and to discover substances which would also protect against mutations induced by radiation.

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EC-00075-05 (Continued)

Significant Results: During the past year, two substances have been investigated for protection of Drosophila spermatogenesis against radiation induced genetic damage. Adenosine triphosphate (ATP), 5 mg/ml, was injected near the testis, and found to decrease X-ray induced dominant lethals in immature spermatozoa and spermatids. In four out of twelve broods (each brood represents a different stage of spermatogenesis at the time of irradiation) there was a significant lower percentage of dominant lethals produced as determined by the failure of the eggs to hatch after 24 hours. The exogenous ATP injections did not reduce the number of radiation induced sex-linked recessive lethals nor did it reduce the percentage of translocations between II and III chromosomes. ATP injections did not influence radiation induced deletion of the X-chromosome and did not decrease the amount of radiation induced crossing-over in the male.

N, N' dimethyl 4, 4' dipyridinium chloride at concentrations of 10 mg/liter was injected into male Drosophila which were then exposed to 1600 R of X-rays. This material did protect against radiation induced dominant lethals in broods day 6 and 8, which represented cells in meiosis and those that were early spermatids. It has the ability to pick up electrons and hence can afford radiation protection. However, the free radicals that are formed do injure the spermatozoma as represented by brood day 11. Other compounds with similar properties are now under investigation.

Publications: No additional publications.

EC-00076-07 (RH-00204-07)

BIOLOGICAL EFFECTS OF LOW VELOCITY ELECTRONS

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Objectives: The purpose of our investigations is to increase our understanding of the method by which electrons and radiations produce their effects.

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EC-00076-07 (Continued)

Although most electrons employed in industry, outer space travel, and medicine, are those of higher velocities, certain knowledge, regarding their action frequently can be discovered only by the use of lower velocity particles.

Significant Results: Investigations include studies of the actions of electrons of different velocities on cellular components such as proteins, enzymes and genes. Typical of the importance of such studies was recently observed at a seminar on work suggested by a representative of the Cincinnati Nuclear Medicine Laboratory of the Bureau of Radiological Health. The participants included physicians, nuclear scientists and radiologists. The questions asked by this group clearly emphasized the relevance of this work to many diverse subjects.

Publications: No additional publications.

EC-00077-06 (RH-00206-06)

RADIOLYSIS OF HETEROGENEOUS SYSTEMS

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Objectives: The objectives of this project are:

1. To determine the modifications to current radiolysis models which are required to explain behavior in heterogeneous systems.

2. To study reaction kinetics in irradiated colloids.

3. To attempt to correlate results in these systems with possible mechanisms of damage and protection in irradiated biological systems.

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EC-00077-06 (Continued)

Significant Results: The most significant results have concerned the colloidal sulfur system. This system is described as follows:

Colloidal sulfur is solubilized upon irradiation with the formation of sulfuric acid. Particle size changes in suspensions of narrow size distribution were followed by light-scattering techniques. Reaction rates have been studied as a function of temperature, particle concentration, radiation intensity and variation in periodicity of irradiation. The picture for the reaction that has evolved from the results of these experiments is the following. Intermediates assumed to be radicals produced in the homogeneous aqueous solution diffuse to the particle surface where they undergo absorption. Certain of these species react with surface sulfur atoms to form precursors of sulfur oxyanions and diffuse away from the surface. Upon continued irradiation the surface population of absorbed intermediates increases and the reaction efficiency decreases.

This is a result of radical-radical reactions between absorbed species or between an absorbed radical and one in the homogeneous phase. A given dose is, therefore, more efficiently administered in short "pulses" (30 seconds or less) than in longer exposures.

The absorbed intermediates have a mean lifetime on the surface of the order of 50-80 seconds. A recovery time of 180 to 200 seconds between exposures is necessary in order that the surface regain a maximum reactivity.

Computer simulated reaction processes are being used to obtain details of this mechanism.

Publications: Baxter, J. N., and Johnston, F. J., "Gamma Radiolysis Studies of the Chloroacetic Acids," Rad. Res., 33, 311, (1968).

Donaldson, G. W., and Johnston, F. J., "The Radiolysis of Colloidal Sulfur," J. Phys. Chem., 72, 3552, (1968).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00078-06 (RH-00210-06)	NEOPLASMS IN IRRADIATED HUMAN POPULATIONS	LOUIS H. HEMPELMANN UNIVERSITY OF ROCHESTER ROCHESTER, NEW YORK

Objectives: To investigate induction of cancer and benign tumors in man by radiation exposure in a continuing study of 4,872 persons. These people have a history of receiving radiation therapy, usually in childhood. As controls, 7,752 non-irradiated siblings of the irradiated subjects will be used. In particular, the mechanisms by which the irradiation of the thyroid induces cancer will be studied and the best means of treating and/or preventing this disease will be explored.

Significant Results: Three significant developments have occurred during the past year in the study of persons irradiated in childhood and followed for the past 16 years. The first of these is concerned with the treatment of patients with radiation-induced thyroid neoplasms by suppressive therapy with thyroid hormone. Of 19 patients so treated for periods up to five years, it was found that those with early lesions which present as solitary nodules to palpation usually respond well to suppressive therapy with complete or almost complete disappearance of the nodules in about half of the cases. In contrast, patients with more extensive and, presumably, older, multinodular lesions do not respond as well. Complete suppression of thyroid function does not prevent neoplastic transformation completely as observations have been made of two new nodular lesions to develop under these conditions.

The second significant development in the study has to do with the chromosome aberrations in the thyroid cells of patients irradiated with X-rays or I^{131}. Previously, it was observed that surgically removed and cultured thyroid cells of adults exposed to X-rays in infancy have a very high incidence of chromosome aberrations. Since those patients were given I^{131} for uptake studies and thyroid scans just before operation, it could not be decided whether the chromosome damage had been inflicted by the X-ray exposure many years before or by the more recently administered I^{131}. Recent control studies of patients with thyroid tumors given I^{131} but not treated with

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EC-00078-06 (Continued)

X-rays and in patients not exposed to either I^{131} or X-rays indicate that dose of I^{131} do not seem to cause an increase in detectable chromosome aberrations. If true, this development is very important to assess the hazards of I^{131} fallout.

The third development is the fourth mail survey of the 2,878 persons treated with X-rays in infancy for thymic enlargement. The survey which is about three-quarters finished has not yet been analyzed but many more surgically removed tumors have occurred especially in the thyroid gland. One case of myesthenia gravis with a tumor of the thymus gland has also occurred.

Publications: Pifer, J. W., Hempelmann, L. H., Dodge, H. J., and Hodges, F. J. II, "Neoplasms in the Ann Arbor Series of Thymus-Irradiated Children; A Second Survey," Am. J. Roentgenology, Radium Therapy Nuc. Med., 53 (1968).

Hempelmann, L. H., "Risk of Thyroid Neoplasms After Irradiation in Childhood," Science, 160, 159 (1968).

EC-00079-07 (RH-00218-07)

β-IRRADIATION EFFECTS ON DERMAL VASCULAR PERMEABILITY

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PHILADELPHIA, PENNSYLVANIA

Objectives: Studies will be conducted on both early and late increases in the permeability of blood vessels of beta-irradiated skin. The efficacy of various anti-inflammatory drugs to suppress these vascular changes and the subsequent ulceration will be evaluated. Insight into the mechanism(s) responsible for these changes is expected to result from these studies by choosing drugs with different sites of action. It is hoped to find a combination of drugs which will suppress the permanent skin injury associated with radiodermatitis. In addition, attempts will be made to isolate and identify the factor(s) responsible for the radiation induced skin inflammation.

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EC-00079-07 (Continued)

Significant Results: An evaluation is being continued of various anti-inflammatory compounds with regard to their ability to suppress or alleviate the symptoms of exudative radiodermatitis. Chloroquine, indomethacin, and C1-583 (Meclofenamic acid), which were found to delay and suppress this acute radiation injury when given orally or intraperitoneally, were found to be ineffective topically. Among other vehicles, dimethylsulfoxide (DMSO, 50 and 25 percent) was used for drug solution and to aid in penetration topically. Contrary to some published reports, the use of DMSO resulted in increased exudative radiodermatitis and data indicate that this compound is ineffective alone or in conjunction with anti-inflammatory compounds. The partial purification of a trypsin-like protease from guinea pig skin has been reported. This proteolytic enzyme may have vasoactive properties or behave as a kallikrein in producing vasoactive peptides. Further purification of this protease and its possible involvement in the mechanism(s) responsible for the radiation-induced increase in vascular permeability are in progress. A comparison was made of the free amino acids, ammonia, urea, and pyrrolidone carboxylic acid content of conventional and germ-free guinea pig epidermis. It was found that there was a peak increase in total epidermal free amino acids at about 3 days after 3000 rep beta-irradiation to the skin, and all 20 free amino acids increased per gram wet weight during this interval. The early postirradiation (24 hours) increases in epidermal DNase I (the enzyme which destroys DNA) of beta-irradiation epidermis were shown to be an artifact resulting from clipping of the hair. Beta-irradiation injury enhances this initial response to clipping by the 14th day postirradiation. The basis for the radio-induced persitent hyperplastic (thickened) epidermis is also under investigation, and preliminary cell population kinetic studies indicate that the DNA synthesis interval is the same in the proliferating basal cells of control and hyperplastic epidermis 50 and 150 days after 3000 rep beta-irradiation, but the latter consists of two to three layers of growing basal cells in contrast to a single layer for the nonirradiated epidermis. The turnover times for whole epidermis differed too; the non-irradiated was 8.5 days as compared with 14 days for the regenerated thickened epidermis. It was concluded that in the latter a feed-back control mechanism suppresses further growth and a new steady state of cell turnover at a new population level is established.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00079-07 (Continued)

Publications: Song, C. W., Drescher, J. J., Tabachnick, J., "Effects of Anti-Inflammatory Compounds on Beta-Irradiation-Induced Increase in Vascular Permeability," Rad. Res., 34, 616 (1968).

EC-00080-06 (RH-00239-06)

RADIATION PROTECTION AND RECOVERY IN GERMFREE ANIMALS

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NOTRE DAME, INDIANA

Objectives: To reproduce in germfree mice the pathology seen in conventional mice following whole-body irradiation in order to clarify the etiology of these changes with reference to microbiol activity. The pathology of secondary disease in radiation chimeras is being investigated thoroughly, and with the use of antilymphocyte serum an attempt will be made to obviate even the mild symptoms seen in germfree chimeras and produce true tolerance to the bone marrow graft.

Significant Results: It was postulated that unconjugated bile acids (e.g., cholic acid), which bacteria produce from the conjugated bile acids (e.g. taurocholic acid) released into the intestine, accelerate cellular turnover on the villas, thereby shortening the life span of the cells. Two groups of germfree mice were maintained on a low fat diet for 7 months from weaning. One group received a supplement of 0.15 percent cholic acid and the other received 0.15 percent sodium taurocholate. The migration of the mucosal cells on the villi of these animals was studied by tritiated thymidine labelling of crypt cells in mitosis, sacrificing mice daily after labelling, and histologically following the progress of labelled cells on the villi. The life span of the mucosal cells of those receiving cholic acids was 2 days, comparable to the conventional state. Taurocholate did not alter the migration rate. Furthermore, it took 4 days for the label to disappear from the mucosa of the cholic acid group versus 7 days in the taurocholate group. These data seem to support the hypothesis. The work remains under investigation.

The pathology of secondary disease in radiation chimeras is being investigated thoroughly, and effort is being made to produce true tolerance to bone marrow grafts.

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EC-00080-06 (Continued)

The C3H and CFW mouse strains used in our early experiments were closely bred but not inbred. In order to be certain that the absence of secondary disease in germfree radiation chimeras reflects a picture of a true immunological response uncomplicated by intercurrent infections, a change was made of the experimental animals to two strains of mice that are very different at major histocompatibility loci. The C3H/He mice are H-2^k and share only one "strong" specificity with the DBA/2 mice that are H-2^d.

Adult C3H/He germfree mice (11 weeks of age) of both sexes were exposed to 1000 R of X-radiation; conventional mice were exposed to 825 R. Twenty-four hours after X-irradiation the mice received 10^7 DBA/2 bone marrow cells i.v. Two animals were sacrificed at regular intervals for the 30-day observation period and at weekly intervals thereafter until 18 weeks post-transplant. The peripheral blood, bone marrow, body weight, and the liver, thymus, and spleen weights were measured. Tissues were fixed for histological examination.

A transitory splenomegaly appeared on day 6 post-transplant in both germfree and conventional mice. In the germfree mice spleen weights returned to normal on day 14 and remained at normal levels throughout the observation period. After an initial depression in leukocyte counts, an increase was observed by day 8. Hematocrit values returned to normal by day 12. A persistent increase in both number and size of Peyer's patches was observed by day 28. Recovery patterns were inconsistent in conventional mice. This study remains under investigation at 100 days post-transplant. Tissues are being processed for histological examination at present.

It is postulated that in the absence of complicating infections the germfree animal is better able to adjust to the chimeric state than its conventional counterpart. Clinical applications may become feasible by the use of laminar flow techniques or the "life island" technique for human transplant recipients and thereby ameliorate the response from/to the marrow transplants.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00080-06 (Continued)

Publications: Wilson, R., "The Effects of Micro- ganisms on Radiation Pathology, and Bone Marrow Therapy in Wholebody Irradiation," J. Amer. Osteopathic Assoc., 67, 653 (1968).

Wilson, R. and Matsuzawa, T., "Oxygen Changes in Tissues of Germfree and Conventional Mice After Innoculation of Bacterial Endotoxin," Life Sciences, 7, 1075 (1968).

EC-00081-06 (RH-00268-06)

LOCAL CHEMICAL RADIATION PROTECTION IN MICE

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Objectives: To determine the degree and character of radiation protection afforded by different chemical agents applied directly to the mouse tongue. The chemical agents that will be used are mercaptoethylamine, MEA, aminoethylisothuromiun, AET, and para-aminopropriophenone, PAPP. The assessment of protection will be determined by the ability of these chemicals to alter the mortality of oral radiation death and their ability to prevent or alter the sequence of histologic changes in the irradiated tongue which precede death. It is expected that the results of these studies will provide information which will be necessary for an evaluation of the feasibility of using radiation protection chemicals to protect normal tissues during radiation therapy for cancer.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: Goepp, R. A. and Fitch, F. W., "Radiation Effect on Oral Epithelium in Mice," Paper presented at the Fourth International Conference on Oral Biology, Copenhagen, Denmark, July 15, 1968.

Goepp, R. A., "Topical Chemical Protection Against Oral Radiation Death in Mice," Rad. Res., 34 (1968).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00082-05 (RH 00272-05)	THE AGE FACTOR IN RADIATION SENSITIVITY OF MAMMALS	JOSEPH ROTBLAT ST. BARTHOLOMEWS HOSPITAL MEDICAL COLLEGE LONDON, ENGLAND

Objectives: In mice exposed to ionizing radiation there is an increased incidence of tumors; however, at high doses the incidence decreases, often to a value below that observed in unirradiated mice. The object of the investigation is to test a model which explains this phenomenon in terms of the probability of radiation changing a normal cell into a potential tumor cell, combined with the probability of the radiation deleting this property. It is hoped this model will lead to a better understanding of carcinogenesis and the radiotherapy of cancer.

Significant Results: The age of exposure to radiation has been shown to affect the increase in incidence of leukemia in mice following whole-body irradiation. The peak incidence occurs at a higher dose in the young than in the adult animal.

Leukemia has also been produced in recipient mice, treated to kill their own bone marrow stem cells, and transplanted with donor bone marrow stem cells which have survived different doses of radiation. The leukemia incidence was found to increase with the dose to the donor, reaching a peak at about 200 rads, after which the the incidence decreased. These results demonstrate that the observed decrease in tumor incidence at high doses of radiation is not due to cell killing of potentially leukemic cells. These findings may be of importance for selective treatment of critical stem cell populations during the development of leukemia.

Transplantation experiments in random-bred and inbred mice have shown a marked dependence on age of the development of the rejection reaction between transplanted cells and the recipient. This is seen as an increased number of delayed deaths (60-140 post irradiation), which is about three times higher in the 30-week-old survivors than in the 6 week old survivors, and is not due to the higher acute mortality (0-60 days

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post irradiation) in the 6-week-old group resulting from an accelerated rejection reaction at this age. Delayed mortality, which is due to the graft versus host reaction, cannot be modified by prior irradiation of the donor cells.

The late effects of whole-body irradiation on the bone marrow stem cells has been measured in mice surviving 18 months after 800 rads given at 16 weeks old. The number of stem cells was not different from that in unirradiated mice of the same age, but this was due to a larger proportion of the stem cell population being in cell cycle in the irradiated mice. Thus 31 percent of the bone marrow cells were killed by tritiated thymidine incorporation compared with 5 percent in the controls. The relevance of these data to the study of late effects in man is being examined.

Studies on the production of tumors in the lungs of mice after low doses of radiation with or without administration of urethane, have shown no age dependence on the yield of tumors. This is probably due to the fact that there is a similar number of cells at risk in the lungs of all ages after 10 weeks old.

Publications: No additional publications.

EC-00083-06 (RH-00279-06)

DISPLACEMENT REACTION OF ANTI-RADIATION DRUGS

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Objectives: To study the chemistry of sulfur containing irradiation drugs with specific reference to the ease of their ability to function as nucleophiles in S_N2 reactions. These studies of the physical organic chemistry of the irradiation drugs should aid in the interpretation and elucidation of radioprotective mechanisms.

Significant Results: A sound explanation for an effect called the "Alpha Effect" has been offered. Theoretical explanation of this hitherto unexplained fact is now being

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published as a communication to the editor. The Alpha Effect was so named because of the unusual reactivity of materials that have a very electronegative atom adjacent to the reaction center. Numerous drugs fall into this class.

These ideas have been extended particularly in the area of anti-radiation drug protection in which the same phenomena hopefully are being exhibited but even at a greater distance. Indeed, one is able to predict the effect of the change in structure on the nitrogen atom on the fourth atom removed away from the sulfur atom in the compounds closely related to MEA, one of the better anti-radiation drugs.

Future work will center on the use of ESCA Spectra to correlate structure in reactivity, or structure in drug potential. ESCA, a brand new tool for creative research, will make possible determination of the charges on each atom and the energies of each electron within a complex molecule using theory previously developed. It is hoped to be able to correlate the structure in reactivity using ESCA Spectra.

Publications: Davis, R. E., Wagner, E. S., and Guenthner, M. C., "Recent Advances in the Chemistry of the Sulfur-Sulfur Bond," The Chemistry of Sulfides (1968).

Davis, R. E., "The Oxibase Scale," Organosulfur Chemistry (1967).

EC-00084-06 (RH-00280-06)

EFFECTS OF RADIATION AND DRUGS ON HAIR AND HAIR GROWTH

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CHICAGO, ILLINOIS

Objectives: Rapidly dividing hair cells will be used as a model system to study the biological effects of radiation along or combined with drugs, duration of cellular injury and character of recovery. Results of dose fractionation, comparisons of different radiation modalities, and radiation effects on cell division will be investigated. Also electron microscope studies of ultrastructural changes characterizing radiation injury will be conducted.

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Significant Results: The following principal studies were continued or completed in 1969:

1. Previous studies had shown that single doses of 500-1500 rads given to resting mouse hairs reduced the lengths of the succeeding generation of hairs by 5-13 percent. Less than two months later, the second post-radiation hair generation showed complete recovery to normal hair lengths.

In the current study much larger doses of 2000-2500 rads were given to resting hairs to determine whether permanent impairment of hair growth would occur. Reductions in hair lengths of 27-33 percent were still present without recovery ten months post-radiation. Hair regrowth rates were also visibly slowed on the skin surface up to 14 months post-radiation. Skin biopsies taken after administration of radioactive (tritium - labeled) thymidine revealed persistent reductions of 50 percent or more in the number of dividing cells in growth phase hairs.

2. Isolation of single hairs was achieved through microdissection techniques. This method has yielded accurate measurements of hair cell division times in the mouse (12 hours). It has also revealed that hair growth ceases precipitously by abrupt termination of cell division rather than by prolongation of cell division times or gradual cessation of cell reproduction. Currently the technique is being adapted to human hairs to study effects of accidental exposures to large radiation dosages.

3. Studies of ultrastructural radiation in cells of isolated rat whiskers have been continued. Single doses of 1500 rads produce degenerative cytoplasmic changes within 30-60 minutes. Nuclear changes are seen within 16 hours, and defective keratinization results in abnormal thinning and easy breaking of hairs. Damaged cells can still be found three weeks later at the hair base, indicating that this technique is useful for further study of general radiation effects on cell viability, reproductive integrity, and differentiation.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00084-06 (Continued)

Publications: Malkinson, F. D., Lathrop, K., Harper, P. V., "Human Total-Body Retention and Excretory Routes of ^{75}Se From Selenomethionine," Vortage am Gasteiner International Symposium (1968).

Lanzl, L. H., Malkinson, F. D. and Ahrens, T. J., "Depth Dose Studies in Electron Beam Therapy - Effects of Anagen Mouse Hairs," Amer. J. Roentgenology, Radium Therapy, and Nuclear Medicine, 53 (1968).

Malkinson, F. D., Griem, M. L., "Radiation Injury and Recovery in Anagen and Telogen Rodent Hairs," Rad. Res., 33, 554 (1968).

EC-00085-05 (RH-00298-05)

FOLLOW-UP STUDY OF IRRADIATED TINEA CAPITIS CASES

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Objectives: To determine the long-term health experience of approximately 2,404 cases of tinea capitis (ringworm of the scalp) treated by X-ray epilation and 1,794 tinea capitis cases not receiving X-ray therapy. The purpose of the study is to characterize the nature and magnitude of chronic radiation injury due to X-ray epilation.

Significant Results: The entire registry has been surveyed once, with about 80 percent case location. This original survey of illness experience demonstrated in the irradiated cases an incidence of confirmed mental illness 2.5x greater than in controls, and an incidence of cancer and leukemia 10x greater, with deaths from malignancy occurring only in the irradiated.

A psychiatric evaluation including psychiatric history/interview and psychological testing was conducted on a subsample of 175 cases. The interview revealed a higher incidence in the irradiated group of: (1) diagnoses of moderate to severe psychiatric disorder (2) history of work problems (3) evidence of paranoid interpersonal relationships and chronic anxiety. Similarly, psychological testing demonstrated a

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higher incidence of personality patterns indicative of conversion hysteria and personality-character disorders.

A repeat survey after approximately 5 years was initiated. The following areas are being evaluated as potential indicators of late radiation injury: illness experience and mortality, with physician and hospital confirmation and death certificates, education, occupational experience, drug usage/abuse, military service. At this time, 52 percent of the original population has been recontacted, with resurvey completed in 76 percent of these and case-finding and follow-through in process for the other 24 percent.

A tabulation of confirmed illnesses to date shows an incidence of:

1. Mental illness in the irradiated 4.5 percent versus 2.4 percent in non-irradiated; psychosis 1.3 percent versus 0.8 percent; personality disorders 1.2 percent versus 0.6 percent; psychoneuroses 2.0 percent versus 1.0 percent.

2. Cancer and leukemia in the irradiated of 0.8 percent versus 0.1 percent in non-irradiated. One death has occurred in each group, both cases due to Hodgkins, bringing total mortality due to malignancy to 16 (0.29 percent) in irradiated, and 1 (0.07 percent) in non-irradiated.

3. Mortality in the irradiated of 1.5 percent versus 0.6 percent in non-irradiated.

4. Tumors and cysts of the head and neck in the irradiated of 3.9 percent versus 2.7 percent in non-irradiated, over 40 percent higher. By comparison, in other parts of the body receiving negligible radiation exposure, the incidence is very comparable (2.6 versus 2.4 percent respectively).

Publications: Albert R. E. and Omran, A. R., "Follow-Up Study of Patients Treated by X-ray Epilation for Tinea Capitis," Archives of Environmental Health, 17 (1968).

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EC-00085-05 (Continued)

Schulz, R. J. Albert, R. E., "III. Dose to Organs of the Head from the X-ray Treatment of Tinia Capitis," Archives of Environmental Health, 17 (1968)

Albert, R. E., Omran, A. R., Brauer, E. W., Cohen, N. C., Dove, D. C., Schmidt, H., Becker, M., Baumring, R., Baer, R. L., "Results of Clinical and Laboratory Examinations," Archives of Environmental Health, 17 (1968).

EC-00086-06 (RH-00304-06)

CELL DIVISION CYCLE AND RADIOSENSITIVITY METABOLIC STUDIES

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Objectives: To correlate cell sensitivity to radiation damage of the metabolic events occurring during the mitotic and meiotic cycle, with the aim of understanding the cellular mechanisms which control differential sensitivity and cellular repair from radiation damage. The study will involve a biochemical analysis of the pattern of macromolecular synthesis during mitosis and meiosis in the mouse and the quantitative evaluation of some radiation effects on cells such as chromosome breakage, cell lethality, and mitotic delay.

Significant Results: One aspect of the research was to characterize the molecular events occurring during early embryonic development and the mechanisms of control of embryonic differentiation, with the aim of understanding some of the effects of ionizing radiations on embryos. Chromatographic observations have demonstrated the existence in sea urchin embryos during cleavage of multiple species of the same t-RNA. The appearance during cleavage of different species of the same t-RNA, characterized by different anticodon properties, might be the mechanism for the activation of stable m-RNA molecules during cleavage. This might then be a mechanism of control of embryonic differentiation at the translation level. This work has also shown the appearance at the plutens stage of multiple species of arginil-t-RNA and lysil-t-RNA which are absent in earlier stages. The appearance of these new species of t-RNA might be related to the synthesis of new histones at this stage. The problem of

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immediacy of genetic control during cleavage has been approached in the mouse using metabolic inhibitors. The results obtained were interpreted to indicate that a large fraction of protein synthesis and development of mouse embryos in culture from the 2-cell stage to the blastocyst stage is regulated by a continuous gene action, although a fraction of protein synthesis exists which is independent of a simultaneous gene activity. This fraction is probably dependent on stable RNA molecules synthesized during oogenesis. This work has also shown that actinomycin and puromycin are ineffective in inhibiting development and protein synthesis in early mouse embryos when administered during the G_2 period of the cell cycle. This result is interpreted to indicate that the events of transcription and translation related to division are completed at the end of the S period. This fact might be relevant to the problem of differential sensitivity to radiation of different stages of the cell cycle.

Another line of research was the biochemical analysis of the cell cycle in mitotic cells in culture. The work has continued to characterize the mode of duplication of ribosomal cistrons during the cell cycle in Chinese hamster cells cultured in vitro.

Publications: Monesi, V., "Ribonucleic Acid and Protein Synthesis During Differentiation of Male Germ Cells in the Mouse," Archives D'Anatomie Microscopique et de Morphologie Experimentale.

EC-00087-05 (RH-00307-05)

BIOLOGICAL ENRICHMENT CHAINS OF RADIONUCLIDES IN FINNISH LAKES

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HELSINKI, FINLAND

Objectives: The purpose of the project is to elucidate the limnological factors affecting the accumulation of the biologically most important radionuclides in fresh water organisms, especially fish. Food chains of ^{137}Cs from the global fallout will be studied in 12 lakes of limnologically different types (from nutrient deficient

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ones to those rich in nutrients). In addition, isotope labelling experiments will be carried out with ^{137}Cs, ^{85}Sr, ^{131}I, ^{140}Ba and ^{45}Ca in five lakes of different limnological types in order to determine quantitatively the changes with time in the distribution of the isotope between different compartments of the lake biosystem.

Significant Results: Since 1963 the ^{137}Cs content of water plants, plankton and various fish species in 10 Finnish lakes have been followed. In most species maximum values were observed in eutrophic lakes in 1964 and in oligotrophic lakes in 1965. Since then the ^{137}Cs contents have decreased exponentially with an apparent half-time of 2 to 4 years in plankton and fish and 3 to 4 years in the plant species studied. The rate of decrease also depends on the trophic type of the lake, being usually faster in eutrophic lakes.

A total balance experiment was carried out in a small dysoligotrophic lake by pumping 4 mCi ^{131}Ba from a moving boat and mixing it homogeneously into the productive layer. For several weeks water, plankton, plants and fish were analyzed periodically. Accumulation of the nuclides continued in most species for 5-7 days, when their equilibrium was reached. Enrichment factors reached (pCi/kg fr wt/pCi/litre water) were in plankton 4 - $26 \cdot 10^5$, in plants 700-1800, and in fish 2000-4000 except in small perch where it was 2300. The uptake of barium was much slower than that of calcium, which was studied earlier. During the whole experiment only 40 percent of ^{131}Ba was removed from the water, while this removal of calcium took place on the first day of the experiment.

Publications: Miettinen, J. K., Takatalo, S., and Kolehamainen, S., "A Tracer Experiment with I-131 in an Oligotrophic Lake," Symposium on Radioecology. May 15-17, 1967. Ann Arbor, Michigan.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00088-06 (RH-00311-06)	IRRADIATION MARROW TRANSPLANTATION IN LARGE ANIMALS	E. DONNALL THOMAS UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

Objectives: To investigate protection against the lethal effects of whole body irradiation by bone marrow transplantation. Two major and necessary correlative studies include:

1. Methods of maintaining life during periods of bone marrow failure. These techniques will include maintenance of electrolyte and water balance, prevention and control of infection, provision of platelets and provision of large numbers of granulocytes.

2. Studies of the immunological complications of marrow transplantation. These will include studies of the nature of the immunologic reactions responsible for graft rejection or graft-versus-host disease and studies of means of control of immunologic reactions using immunosuppressive drugs, antilymphocyte serum and extracorporeal irradiation.

Significant Results: The individual exposed to a high dose of whole body irradiation is in danger of death from bleeding and infection because of destruction of the very sensitive bone marrow that produces platelets and white blood cells. A transplant of normal bone marrow would obviously be desirable, but the physician caring for such a patient is confronted with a dilemma in that (a) if the irradiation exposure is sublethal a transplant is not needed and might be dangerous since there is evidence in mice that an attempted marrow transplant might be harmful, or that (b) if the transplant is successful there is danger of graft-versus-host disease. Clearly the risk of graft-versus-host disease should be accepted if lethality is certain otherwise, but the irradiation exposure is not usually known with certainty in irradiation accidents. Accordingly, it seemed worthwhile to explore, in dogs, radiation exposures (400-600 R) that are in the range of midlethal to lethal doses. The studies were

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carried out under well-standardized conditions where marrow grafts are consistently achieved after very high radiation exposures (1200 R). Unrelated donors and recipients were used.

A comparison of survival times, white blood cell and platelets counts and marrow histology at all 3 radiation exposures showed no difference in the animals given marrow and the controls. Marrow grafts did not occur and no harmful effect of the marrow transplant could be demonstrated. On the other hand, dogs whose own marrow had been frozen prior to the experiment and readministered after the irradiation exposure all survived. It is likely, therefore, that the irradiation accident victim will not benefit from an attempted marrow transplant unless marrow from an identical twin or close relative or marrow selected by histocompatibility typing is available.

In another study involving unrelated dogs, the marrow from the donor was preserved by freezing to -80°C in 10 percent dimethyl sulfoxide. (Earlier studies had shown that marrow can be kept for years at low temperatures.) At the time of freezing the marrow was "typed" using 8 canine histocompatibility typing sera. After administration of 1200 R to the recipient, the donor marrow was thawed and administered intravenously. The results in 10 recipients that were matched with their donors were compared with the results in 10 mismatched recipients. The results showed clearly that matched recipients survived significantly longer than did the mismatched ones. Two of the matched dogs became permanent chimeras and are alive and well more than one year later. These experiments indicate the feasibility of setting up a "marrow bank" using human marrow that has been typed histocompatibility typing sera that have been developed in connection with the human kidney transplant program. From such a pool of preserved marrow specimens, an appropriate donor marrow could be selected on the basis of the recipient's histocompatibility type.

Publications: Forkey, D. J., Jackson, K. L., and Christensen, G. M., "Contribution of Bile to Radiation-Induced Sodium Loss Via the Rat Small Intestine," Int. J. of Radiation Biology, 14 (1968).

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EC-00088-06 (Continued)

Storb, T., Epstein, R. B., Buckner, C. D. and Thomas, E. D., "Treatment of Chronic Lymphocytic Leukemia by Extracorporeal Irradiation," Blood, 31 (1968).

Thomas, E. D., Storb, R., Buckner, C. D., Epstein, R. B., Graham, T., "Clinical and Hematologic Effects of Cross Circulation in Baboons," Transfusion, 9 (1969).

Thomas, E. D., Epstein, R. B., Storb, R., Ragde, H., "Cytotoxic Typing Antisera for Marrow Grafting in Littermate Dogs," Transplantation, 6 (1968)

Thomas, E. D., Storb, R., Epstein, R. B., Rudolph, R. H., "Symposium on Bone Marrow Transplantation: Experimental Aspects in Canines," Transplantation Proceedings, 1 (1969).

Marchioro, T. L., Hougie, C., Ragde, H., Epstein, R. B., Thomas, E. D., "Hemophilia: Role of Organ Homografts," Science, 163, 188 (1969).

Storb, R., Epstein, R. B., Thomas, E. D., "Marrow Repopulating Ability of Peripheral Blood Cells Compared to Thoracic Duct Cells," Blood, (1968).

Storb, R., Epstein, R. B., Bryant, J., Ragde, H., Thomas, E. D., "Marrow Grafts by Combined Marrow and Leukocyte Infusions in Unrelated Dogs Selected by Histocompatibility Typing," Transplantation, 6 (1968).

EC-00089-05 (RH-00330-05)

LOW LEVEL GAMMA RADIATION AND PHYSIOLOGICAL PERFORMANCE

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COLLEGE STATION, TEXAS

Objectives: To test the effects of virtually continuous (20 hours per day) exposure to various relatively low doses of ionizing radiation on the ability of the test animal, the Spanish goat, to perform both reproductively and physiologically.

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Significant Results: During this terminal year the 7 R and 2 R per day animals reached their median to death time. As in other exposure groups of this series the females succumbed to these low levels of radiation before the males. The median survival time for 7 R exposed animals was 366 days for females and 1152 days for males. A group of goats were exposed at an intermediate exposure level of 15 R per day to bridge the gap between the 7 R and 30 R per day exposures. The median survival time for these 15 R per day exposed animals was 161 days for females and 240 days for males. In addition to these data the hematological studies, physiological performance studies and semen analysis studies were included and the data presently being processed.

Publications: Szabuniewicz, M., Davis, R. H. Jr., Brown, S. O., aided by Krise, Dr. G. M., "The Terminal Electrocardiogram In Irradiated Goats," The Southwestern Veterinarian, 21 (1968).

Austin, J. W., Hupp, E. W., Krise, G. M., Brown, S. O., "Semen Production of Continuously Irradiated Spanish Goats," Rad. Res., 31 (1967).

Szabuniewicz, M., Clark, D. R., aided by Krise, Dr. G. M., "Analysis of the Electrocardiograms of 100 Normal Goats," Am. J. Vet. Res., 28 (1967).

Krise, G. M., Hupp, E. W., Austin, J. W., "Survival of Goats During Continuous or Interrupted Continuous Irradiation," Rad. Res., 31 (1967).

EC-00090-03 (RH-00364-03)

EEG AND BEHAVIORAL EFFECTS OF GAMMA RADIATIONS

DANIEL E. SHEER
UNIVERSITY OF HOUSTON
HOUSTON, TEXAS

Objectives: To develop a clearly defined index of electricalactivity which can be followed at different levels of the brain--peripheral, subcortical, and cortical--

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and to investigate effects of irradiation on the nervous system. Other objectives are concerned with establishing relationships of behavioral effects to irradiation.

Significant Results: The research has focused on the comparative effects of whole body and head only irradiation in cats. With groups of head only irradiation from 800 to 1200r, there were no consistent effects on the power spectral analysis of the EEG and performance in a visual discrimination task. With whole body irradiation at 500r there were consistent differences in electricity from olfactory bulbs and limbic structures at 3 and 24 hours post, a return to pre-irradiation by 72 hours, and a change again in electricity and also behavior at from 7 through 14 to 17 days when death ensued.

With head only irradiation at 500 to 1000r, there were no changes either in the analyses of the EEG or behavioral performance immediately after irradiation and up to 90 days post. With head only irradiation at 2000 to 3000r, the same changes in brain EEG and behavior were observed as with whole body irradiation--a change in the electrical activity with no deficit in behavior at 3 to 24 hours; a return to the pre-irradiation EEG at 72 hours, and a change again in the electricity with behavioral deficit at 7 through 20 days when death ensued.

There were the same reversible EEG effects with both 500r whole body and 2000 to 3000r head only irradiation, which appeared to implicate chemical mediation through the blood system. This was confirmed by relations between the successive electrical changes and brain serotonin levels in both the whole body and head only irradiation groups. There also appeared to be a time-dependent effect of up to 7 days post-irradiation on the behavioral measures for both the whole body and head only irradiation groups which requires further analysis.

Publications: No additional publications.

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EC-00091-05 (RH-00392-05)	EFFECT OF RADIATION ON PROTEINS AND RELATED COMPOUNDS	WILLIAM F. FORBES UNIVERSITY OF ROCHESTER ROCHESTER, NEW YORK

Objectives: To investigate how free radicals interact with biological materials and to investigate the mechanisms of such interactions.

Significant Results: The effect of radiation on amino acids and proteins has been extended by studying the effects of ultraviolet light on a series of L-tyrosines and their polymers. A number of products have been obtained from among the irradiated samples and these are being identified.

Collagen samples have been obtained from genetically homogeneous mice of different age groups and from mice which have been exposed to ionizing radiation. The collagen samples were obtained from the skins of mice and separated into "neutral salt soluble," "acid soluble" and "insoluble" fractions. The properties of these fractions have been investigated, using a number of different techniques including amino acid analysis, solubility and behaviour on starch gel electrophoresis. The aim of this work is to investigate in which sense the effects of age and of radiation are similar.

The radicals obtained on heating 3,4-benzpyrene have been further investigated and a new radical has been identified in the presence of air. The radical is a phenoxy radical and is very readily formed in the presence of biological materials from 3,4-benzpyrene. It is also obtained from 5-hydroxy-3,4-benzpyrene in good yield and this aids in its identification. Somewhat surprisingly, the latter compound, which readily gives rise to the phenoxy radical, is biologically inactive, although 3,4-benzpyrene is a potent carcinogen. The reason for this is being investigated.

Publications: Lerman, S., Zigman, S. and Forbes, W. F., "Insoluble Protein Fraction of the Lens," Exptl. Eye Res. 7, 444 (1968).

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EC-00091-05 (Continued)

Forbes, W. F. and Cooper, J. T., "ESR Study of the Dimer Cation of Coronene," J. of Chem. Phys., 49, 1190 (1968).

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GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00092-04 (RH-00394-04)	RADIOLYSIS OF SIMPLE ORGANIC NITROGEN COMPOUNDS	NORMAN N. LICHTIN BOSTON UNIVERSITY BOSTON, MASSACHUSETTS

Objectives: This research is directed toward elucidation of mechanisms of radiolysis of simple amides, amines and other organic nitrogen compounds. Interest centers on establishing chemical processes characteristic of each class of compound, on generalizing models of the radiolytic dynamics of polar molecules, and on providing an improved basis for understanding of radiation damage to biologically active molecules. Information on the nature and amounts of stable products, on the influence of dose rate, quality of radiation and scavengers on these, and on the nature and kinetics of observable transient species is being collected.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

EC-00093-04 (RH-00404-04)	DIGITAL COMPUTING TECHNIQUES IN RADIOLOGICAL PROBLEMS	JOHN L. HOWARTH UNIVERSITY OF NEW MEXICO ALBUQUERQUE, NEW MEXICO

Objectives: The application of computer techniques to radiological problems with particular reference to the following:

1. The computation of doses near boundaries in inhomogeneous media irradiated with ionizing radiations, with particular reference to soft-tissue cavities in bone.

2. The development of mathematical models for the growth and dissemination rates of malignant tumors.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00093-04 (Continued)

3. Calculations of the gamma-ray energy absorbed in bodies of different shapes containing distributed radioactive materials, and of other miscellaneous data of interest in radiology.

Significant Results: Further calculations have been made of doses near boundaries in inhomogeneous absorbers irradiated with X-rays with particular reference to soft tissue cavities in bone. The theory has been extended to cover continuous X-ray spectra. Some further progress has been made in deriving mathematical models for growth and dissemination rates of malignant tumors, with the intention of improving estimates of prognosis in such cases.

Publications: No additional publications.

EC-00095-03 (RH-00429-03)

CHELATION IN RADIATION PROTECTION CHEMICALS

SEYMOUR S. BLOCK
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GAINESVILLE, FLORIDA

Objectives: To better understand the mechanism of chemical protectants against ionizing radiation and to be able to produce more effective and useful materials. More specifically, it is planned to synthesize and study the effect of protectant compounds that are capable of chelation. The effect of chelation on radiation protection is being investigated by producing a series of compounds that have the same reactive structure and are known to chelate and to be radioprotective, but to introduce substitutents in the nonreactive part of the molecule, which will influence the electrical properties and thereby the ability to chelate.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00096-04 (RH-00431-04)	RADIATION PROTECTION AND MEASUREMENT	LAURISTON S. TAYLOR NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS WASHINGTON, D.C.

Objectives: 1. To collect, analyze and disseminate information and recommendations for radiation protection and measurement; and

2. To stimulate the exchange of ideas in radiation problem areas.

The Council formulates recommendations on radiation protection and measurements which represent the leading scientific thinking on these questions and are of substantial benefit to those utilizing radiation producing equipment or materials.

Significant Results: Principal activity centered around the following areas, each with its own Scientific Committee: Basic Radiation Protection Criteria, Heavy Particles (Neutrons, Protons and Heavier), Medical X- and Gamma-Ray Protection up to 10 MeV (Structural Shielding Design), Safe Handling of Bodies Containing Radioactive Isotopes, X-ray Protection in Dental Offices, Veterinary X-ray Protection, Brachytherapy. New or pending publications included NCRP Report No. 34 "Medical X-ray and Gamma-Ray Protection for Energies Up to 10 MeV -- Structural Shielding Design and Evaluation," a revision of NCRP Report No. 17, "Permissible Dose from External Sources of Ionizing Radiation," and new recommendations for dental X-ray protection, hazards from heavy particle radiations, handling of patients having received therapeutic amounts of radionuclides, veterinary radiation protection and procedures in brachytherapy. In addition the Council devoted attention to the problems associated with internal emitters and identified and set up scientific evaluation efforts in the following seven areas: radiation hazards resulting from the release of radionuclides into the environment; radionuclides and labeled organic compounds incorporated in genetic material; physical and biological properties of radionuclides; selected occupational exposure

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00096-04 (Continued)

problems arising from internal emitters; administered radioactivity; dose calculations; and maximum permissible concentrations for occupational and nonoccupational exposure.

Publications: National Council on Radiation Protection and Measurements, "X-ray Protection Standards for Home Television Receivers."

National Council on Radiation Protection and Measurements, "Medical X-ray and Gamma-Ray Protection for Energies Up to 10 MeV."

EC-00097-03 (RH-00433-03)

RADIATION STUDIES IN IONIC MATRICES

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UNIVERSITY PARK, PENNSYLVANIA

Objectives: Simple inorganic and organic ions, which are present in biological systems or which can serve as chemical models of more complex biological compounds, are dispersed in solid potassium halide matrices, and these solids are exposed to ionizing radiations. The chemical changes of the solute ions produced in these samples will be characterized by measuring the infrared, ultraviolet, visible, and/or electron paramagnetic resonance spectra of the samples.

Significant Results: The carbon dioxide anion free radical (CO_2^-) and the carbonate anion free radical (CO_3^-) are produced during the radiation damage of carbonates, bicarbonates, or carboxylates. These very reactive free radicals have been trapped in potassium chloride (KCl) and potassium bromide (KBr) matrices in sufficient concentrations and studies have been made of some of their important chemical reactions.

The CO_2^- radical reacts rapidly with water and produces the formate (HCO_2^-) and the bicarbonate ($HOCO_2^-$) ions. However, in the absence of water, this free radical decays by a bimolecular process and gives only diamagnetic products. The decay reaction rate constants in KCl and KBr matrices are respectively:

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EC-00097-03 (Continued)

$10^{9.37 \pm 0.10} \exp[(-18{,}93 \pm 0.20 \text{ kcal})/RT]$ liter/mole-second,

$10^{6.59 \pm 0.08} \exp[(-11.89 \pm 0.15 \text{ kcal})/RT]$ liter/mole-second.

The principal reaction products in both matrices are the carbon monoxide gas (CO) and the carbonate ion (CO_3^{2-}), but some oxalate ions ($C_2O_4^{2-}$) are also produced in the KCl matrix. Thus, the reaction mechanism for the decay of this radical in the absence of water is as follows:

$$2\,CO_2^- \rightarrow [OCO\text{-}CO_2]^{2-} \rightarrow CO + CO_3^{2-} \quad \text{(principal)},$$

$$2\,CO_2^- \rightarrow [O_2C\text{-}CO_2]^{2-} \rightarrow C_2O_4^{2-} \quad \text{(minor)}.$$

The CO_3^- free radical does not appear to react with water, but its decay in KCl and KBr matrices is also bimolecular. The experimental decay rate constants for the respective matrices are:

$10^{14.8 \pm 0.8} \exp[(-10.3 \pm 0.4 \text{ kcal})/RT]$ liter/mole-second,

$10^{11.9 \pm 0.8} \exp[(-9.6 \pm 0.5 \text{ kcal})/RT]$ liter/mole-second.

The decay product or products are diamagnetic, relatively stable thermally, and show a blue color. Dissolution of the reaction system in acidified water gives a positive test for peroxide. The known peroxy-dicarbonate ion ($C_2O_6^{2-}$) exhibits these properties, and it is suggested that the decay mechanism of our CO_3^- free radical is as follows:

$$2\,CO_3^- \rightarrow O_2COOCO_2^{2-} \quad \text{(peroxy-dicarbonate ion, blue color)}$$

$$C_2O_6^{2-} + \text{acid} \rightarrow 2\,CO_2 + H_2O_2$$

or

$$C_2O_6^{2-} \xrightarrow{\text{heat}} 2\,CO_2 + O_2^{2-}.$$

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00097-03 (Continued)

Since the CO_2^- and CO_3^- free radicals are iso-electronic (same number of electrons in the molecules) with the well known free radicals NO_2 and NO_3, respectively, much of the chemistry of our anion radicals can be understood from the known behavior of the nitrogen oxide radicals.

Publications: No additional publications.

EC-00098-04 (RH-00434-04)

RADIATION CHEMICAL STUDIES ON HEMOCYANINS

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Objectives: Without oxygen, man and other mammals die within minutes. Of allied interest is the fact that cancer cells are more easily killed by irradiation when a high concentration of oxygen is maintained around the normally oxygen-deficient cancer cells. Oxygen from the air becomes available through proteins known as oxygen-carriers--homoglobin in mammals and hemocyanin in primitive marine animals such as crabs and snails. Hemoglobin picks up oxygen from the blood through iron atoms which form an integral part of the protein structure while hemocyanin uses copper instead of iron for oxygen-carrying. In both cases, atomic radiation interferes with the ability of these proteins to pick up oxygen. The objective of this project is to find out why and to devise means for preventing or reversing the process.

Significant Results: In studies with hemocyanin it has been shown that the abilfty of hemocyanin to carry oxygen depends on what is called the oxidation state of the copper. When the protein-bound copper is in a lower oxidation state, the +1 or cuprous form, the hemocyanin picks up oxygen. However, when the copper is in a higher oxidation state, the +2 or cupric form, the hemocyanin cannot pick up oxygen. It turns out that irradiation transforms cuprous copper to the non-oxygen carrying cupric state by producing so-called oxidizing substances, either hydrogen peroxide when oxygen is present or by a reactive chemical species, the so-called hydroxyl free radical, which is formed even when oxygen is not present. Consequently, by removing

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00098-04 (Continued)

hydrogen peroxide or the oxidizing free radical, it is possible to prevent the loss of oxygen-carrying by hemocyanin during or after irradiation. The substances which remove hydrogen peroxide or the oxidizing free radical so that they cannot damage the oxygen-carrying properties of hemocyanin are called scavengers. An effective one is a simple, harmless compound called sodium formate.

It is possible to cause hemocyanin which had lost its oxygen-carrying ability by irradiation to regain this ability by giving the protein more irradiation! This seemingly strange result arises from the fact that irradiation also produces a reducing free radical, called the hydrated electron, which is capable of reducing the protein-bound cupric copper, which cannot carry oxygen, to the cuprous state, which does carry oxygen. Therefore, the irradiated hemocyanin with cupric copper is further irradiated in the presence of the scavenger, sodium formate, which removes the competing oxidizing radical allowing the reducing radical to function without competition. Consequently, the cupric form of the copper is readily reduced to the cuprous form, and the oxygen-carrying ability of the hemocyanin is restored.

It is also possible to cause the radiation damage to be markedly enhanced by removing the reducing radical during irradiation. This has been done by irradiating hemocyanin in the presence of a hydrated electron scavenger, another simple compound called sodium chloroacetate.

Of further interest is the fact that in the case of hemocyanin obtained from one species of marine life, the horseshoe crab, irradiation does not restore the oxygen-carrying ability even though the copper of the protein has all been reduced to the cuprous form. It appears that when this particular hemocyanin is irradiated, the attachment of the copper to the protein is changed slightly, so that the delicate structural features needed for oxygen-carrying are altered.

Publications: Schubert, J., White, E. R. and Becker, L. F. Jr., "Radiation Chemical Studies on Oxygen-Carrying Proteins: Hemocyanin," Advances in Chemistry Series, No. 81, (1968).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00098-04 (Continued)

Schubert, J., Sharma, V. S., White, E. R., Bergelson, L. S., "Catalytic Decomposition of Hydrogen Peroxide by Copper Chelates and Mixed Ligand Complexes of Histamine in the Presence of Phosphate Buffer in the Neutral pH Region," J. of the Am. Chem. Soc., 90:16, (1968).

EC-00099-16
(RH-00443-16)

PRECISION DOSIMETRY IN CLINICAL RADIOLOGY

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PHILADELPHIA, PENNSYLVANIA

Objectives: A long range aim of this research is to explore exhaustively the contribution of the discipline of radiological physics to the field of patient exposure and image quality control in diagnostic radiology. Specifically, there are three areas of interest: (1) Analysis of Complete System Functions (2) Analysis of System Variables (3) Quality Control of Systems Performance.

Significant Results: Several areas of research in dosimetry have received attention. Work has been submitted for publication or presented at professional meetings on *in vivo* dosimetry using extruded lithium fluoride rods and on an X-ray spectrophotometric method using a silicon (lithium drifted) detector for determining *in vivo* antimony deposits in the lung. Theoretical aspects of serial direct magnification in cerebral angiography, patient dose calculation methods, and determination of kVp of diagnostic X-ray generators are the subjects of recent published work.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00101-04 (RH-00455-04)	COMPARATIVE EFFECTS OF TWO RADIATION EXPOSURE REGIMES	DONALD G. WILLHOIT UNIVERSITY OF NORTH CAROLINA CHAPEL HILL, NORTH CAROLINA

Objectives: The purpose of this project is to study the influence on the life span of mice of the manner in which radiation exposure is spread out in time. Most models (theories) of radiation action assume that the most important factor is the overall exposure time in which a specified dose is given, and that the manner of fractionation within this overall period has little effect. This is also the basis of current "radiation protection guides."

Significant Results: Results obtained thus far for survival times characteristic of hematopoietic death indicate that daily fractionated exposure is more effective than continuous exposure delivered at the same daily rate. The usual way to compare the effectiveness of two radiation patterns would be to specify the reciprocal of the ratio of doses that result in a given biological end point, such as death. The effectiveness of the fractionated exposure regime relative to continuous exposure varied from 1.1 to 1.3 depending on the survival time selected for the determination. It was observed however, that survival-time versus daily exposure rate curve for the fractionated exposures was parallel to the curve for continuous exposures, but off-set to the left by about 30 R/day. That is, to produce the same survival time with continuous radiation exposure as with daily fractional exposure, the continuous exposure had to be given at a rate 30 R/day greater than the fractionated exposure. These results can be explained on the basis of a cell survival model developed based on tissue culture studies. These studies are being extended to lower dose rates which may be more applicable to human exposure situations.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00102-07 (RH-00461-07)	TOOTH COLLECTION FOR RADIOACTIVE NUCLIDE STUDY	HAROLD L. ROSENTHAL WASHINGTON UNIVERSITY ST. LOUIS, MISSOURI

Objectives: To determine the accumulation of strontium-90 in fetal bone, deciduous teeth of children, and permanent teeth of young adults and to correlate this accumulation with rates of strontium-90 fallout as it appears in milk and diets. Although major emphasis centers around the St. Louis area, comparative data from other parts of the United States and the world are being gathered. Additional date on total strontium are also being obtained.

Significant Results: The collection of tooth and bone samples, analysis of ^{90}Sr and correlation with dietary ^{90}Sr is continuing and may be divided into various phases:

1. Fetal tooth buds and bone: In the fetus, during the last trimester of development, the nuclide is equally distributed in tooth buds, mandibular bone and femur and represents the contribution of the mother's diet and body burden to the fetus. For fetuses aborted in St. Louis between 1961 and 1970, a period of increasing and decreasing ^{90}Sr fallout, a linear equation of the form $C_T = KC_{m-6}$ is applicable where C_T is the pCi ^{90}Sr/g Ca in fetal bone and C_{m-6} is the dietary pCi ^{90}Sr/g Ca intake of the mother during the first six months of pregnancy and K is a constant equal to 0.3.

2. Deciduous teeth: The ^{90}Sr content of deciduous teeth of infants who were bottle fed from birth represents the fraction incorporated in utero plus the amount obtained from the diet during the first 6 to 9 months after birth. The ^{90}Sr content for all deciduous teeth of children born in St. Louis between 1950 and 1964 are adequately described by a linear equation of the form $C_T = KC_D$ where C_T and C_D are pCi ^{90}Sr/g Ca in the tooth and dietary cow milk, respectively. The constant, K, varies with the kind of tooth, and has been determined for sound incisors (0.6), sound cuspids (0.8), carious first molars (0.7) and carious second molars (0.8).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00102-07 (Continued)

3. Permanent teeth: The crown of sound permanent bicuspids begins to calcify at 1.5 years of age with the midpoint of development occurring at age 5. The ^{90}Sr content of these teeth represents the incorporation of dietary milk nuclide during late infancy and is not influenced by the maternal in utero contribution. The data for bicuspid tooth crowns of children born between 1947 to 1958 are adequately described by a linear equation similar to that for deciduous teeth. For bicuspids, K has been found to be 0.4. The roots of the teeth are also being studied with respect to time of formation, date of extraction and rates of turnover for strontium and calcium.

4. Complementary studies are in progress for deciduous teeth with respect to geographic area of birth, for breast-fed versus bottle-fed children and for carious versus sound teeth.

Studies concerning the total strontium content and discrimination factors for crustacea, pelecypods and fishes from sweet and marine waters have been made by atomic absorption spectrometry. Similar studies are in progress for mammalian and human bone and diets.

Publications: Rosenthal, H. L., Austin, S. A., and Eves, M. G. M., "Strontium-90 Content of Sound and Carious Human Deciduous Teeth," Archs. Oral Biol., 13, 357 (1968)

EC-00103-03 (RH-00464-03)

ESR ABSORPTION OF IRRADIATED ORGANIC CRYSTALS

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UNIVERSITY, ALABAMA

Objectives: With the use of the electron spin resonance (ESR) technique, it has been discovered that chemical reactions in X-ray irradiated crystals of some organic compounds are very similar to enzymatic reactions. This project is intended to clarify the nature of these reactions. Since no such reactions are observed in ordinary organic reactions, it is hoped that this investigation will provide unique knowledge which will be useful for interpretation of the mechanism of radiation damage of biological systems.

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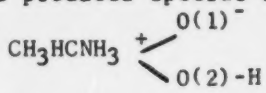
EC-00103-03
(Continued)

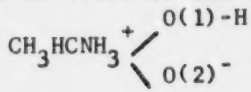
Significant Results: The following three works have been completed:

1. "ESR Study of Stereospecific Transfer in Irradiated Crystals of L-Alanine."

The proton transfer in the crystal irradiated at 80°K was found to be stereospecific: The produced species was shown to be



and no evidence for its chemically equivalent species



was detected. A semi-quantitative model based on quantum-tunneling accounted for this stereospecific reaction satisfactorily. It is believed that this is the first case in which a quantum-mechanical treatment, though semi-quantitative, has been successfully applied in interpreting stereospecificity, which is one of the characteristics of the enzymatic reactions.

2. "ESR Study of Irradiated Crystals of L-Alanine: Two New Proton-Deuteron Exchange Reactions."

These two new proton-deutron exchange reactions were discovered with the use of alpha-deutero-L-alanine. Exchange I was shown to occur between the alpha-deuteron of the radical $CH_3\dot{C}DR$ and the methyl proton of the adjacent molecule, and exchange II was shown to occur between the methyl proton of the radical and the alpha-deuteron of the adjacent molecule. Both exchanges were found to be much faster than the previously reported one (exchange III). Especially, exchange I, which is the fastest, was found to be as fast as the exchange of L-alanine catalyzed by the enzyme transaminase. It should be noted that the catalytic actions of platinum, strong acids, and strong bases are much less effective compared to that of the transaminase.

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EC-00103-03 (Continued)

It is felt that with these two works one of the aims of this research project has almost been accomplished, that is establishment of similarities between the enzymatic reaction and the chemical reaction in an irradiated crystal. The nature of the similarities is yet to be clarified.

3. "ESR Study of Quantum Tunneling of a Methyl Group: A Simple Tunneling Model."

This work was done as the first step to clarify the quantum-mechanics of the proton-tunneling in an irradiated crystal.

Publications: Gamble, W. L., Miyagawa, I., and Hartman, R. L., "Some Effects of Quantization of Internal Rotation on Spin-Lattice Relaxation and Hyperfine Structure," Physical Review Letters, 20, 415 (1968).

Miyagawa, I., Tamura, N., and Cook, J. W., "ESR Study of Stereospecific Proton Transfer in Irradiated Crystals of L-Alanine," J. Chem. Phys., 51, 3520 (1969).

EC-00104-02 (RH-00473-02)

PERCEPTION OF IONIZING RADIATION BY SENSORY SYSTEMS

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Objectives: To obtain information on two vital questions:

1. Can low-level ionizing radiation have an effect on the central nervous system?

2. Can low-level ionizing radiation serve as a stimulus to synchronize physiological rhythms?

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00104-02
(Continued)

Significant Results: Work is being done to determine the structural and functional pathways by which animals are able to perceive ionizing radiation in the ambient environment. Also there is an interest in determining what effect ionizing radiation has on physiological systems. Using the gerbil, Merionies unguiculatus and X-radiation doses of up to 3R/hour on a rhythmic (12 hours on: 12 hours off) basis, it has been shown that ionizing radiation can affect the central nervous systems of rodents. The total body activity rhythms of these mammals have been synchronized to the radiation regime, and it has been possible to alter the activity rhythms by manipulating the radiation regime to which the animals are exposed. This is particularly important in the gerbil as the LD_{50} dosage for this animal is 3 times greater than other rodents. In this radiation resistant animal changes have been observed in normal activity rhythms by simply placing animals in lead shielded rooms. These results indicate that animals can perceive and respond to low levels (just slightly higher than normal background) of ionizing radiation in the ambient environment. The identification of the system which perceives this ionizing radiation is being pursued and preliminary data which indicate the olfactory system is involved has been obtained.

Publications: Mizell, S., Barnes, C. D., Daugherty, J., "Activity Rhythms in the Gerbil," Anatomical Record, 160 (1968).

EC-00105-03
(RH-00479-03)

HEMATOLOGIC RESPONSES TO NON-HOMOGENEOUS IRRADIATION

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CHAPEL HILL, NORTH CAROLINA

Objectives: 1. To determine if changes in the peripheral blood following partial body exposure may be used as indicators of lethal radiation injury.

2. To develop expressions for dose and dose distribution factors for non-uniform radiation exposure.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00105-03
(Continued)

Significant Results: Hemotologic studies were conducted on rats exposed to either whole-body, upper-body, or lower-body X-irradiation. For each of the three exposure conditions studied thus far, there was an immediate drop in the lymphocyte count which was related to the magnitude of the dose. The decrease in the lymphocyte count was greatest under whole-body exposure conditions and least under upper-body irradiation conditions. This is thought to be due to the relative amounts of lymphocyte-producing tissues irradiated. There was a corresponding increase in the neutrophil count 3 to 6 days after exposure in each of the three groups studied and also appears to be related to dose but in a different manner than the decrease in lymphocyte count. An increase in the hematocrit values was observed in the lower-body high-dose group which reflects fluid balance disturbances due to injury to the gastro-intestinal tract. An increase in the hematocrit values was also observed in the upper-body high-dose group but occurred approximately 6 to 9 days after exposure. The results were interpreted in terms of a time-integrated mathematical expression, termed "Cumulative Response Score." This expression enables the time dependent blood responses following irradiation to be expressed as a single number, reflecting both the magnitude and duration of hematologic abnormality. These data indicate that lower-body irradiation is more effective than upper-body irradiation in eliciting hematologic response, due to the amount of bone marrow exposed. The cumulative response score does not however, appear to be a useful predictor of lethal injury for upper-body exposure and only of limited value for lower-body exposure. This is probably due to the fact that other than hematopoietic injury processes are contributing to death from upper and lower body exposures.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00106-04 (RH-00482-04)	CYSTEAMINE AND X-RAYS PRENATALLY: BEHAVIOR OF THE RAT	JOAN M. ROBERTS UNIVERSITY OF DETROIT DETROIT, MICHIGAN

Objectives: To further study the effects on the mental and emotional functioning of offspring whose mothers were exposed to ionizing radiation during pregnancy. Studies with the drug, cysteamine, that have been shown to protect these offspring against the central nervous system damage that often follows radiation exposure are also conducted.

Significant Results: It has been shown that cysteamine (100 mg/kg of body weight) given to the pregnant animal prior to irradiation is protective against neonatal death, motor retardation, and learning deficiencies in the offspring. This was observed following exposure to 110 R or 185 R of gamma-radiation. Cysteamine injected subcutaneously was also investigated to determine whether this route of administration would produce as protective an effect as the intraperitoneal method. Since cysteamine at the dosage given above (low dose) was found ineffective when given after irradiation, another group was given twice the cysteamine dosage (200 mg/kg) immediately following irradiation. The days of pregnancy studied were Day 15 and Day 20 (gestation period of the rat is 22 days).

On two tests of motor development, the upright and the righting response, neonates who received 185 R prenatally developed more slowly than the controls. This was more marked in the groups irradiated on Day 15 on both motor development measures. Those receiving the low cysteamine dose developed earlier than the other groups including the "unprotected" controls (no cysteamine, no irradiation). Cysteamine injected as a control (no irradiation) slowed development slightly but not the the extent seen in the high cysteamine dose group. The high cysteamine groups were remarkably slowed in development even in comparison with the high radiation dose group (185 R) that received no cysteamine. The most retarded of the groups was the subcutaneously-injected high cysteamine group.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00106-04 (Continued)

Data from the Lashley III maze (modified to a water maze), showed a definite inverse relationship between prenatal radiation dose level and postnatal (adult) learning ability, particularly on Day 15. The subcutaneously-injected and the groups receiving the high dose of cysteamine learned significantly more slowly than the "unprotected" high radiation groups. This was seen in both male and female offspring indicating no sex difference in response to cysteamine prior to prenatal irradiation. Marked deficiencies in learning ability were found when cysteamine was given subcutaneously. The cysteamine-after-irradiation groups were also greatly impaired in their learning ability. On Day 20, no protection was offered. However, these animals made fewer errors in learning to traverse the maze than those animals receiving the same dose of radiation (185 r) on Day 15. Differences in the stage of fetal brain development undoubtedly account for this finding.

Publications: No additional publications.

EC-00107-03 (RH-00487-03)

CYTOGENETICS OF IRRADIATED MALE MICE

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BAR HARBOR, MAINE

Objectives: To determine the extent of permanent radiation damage to spermatogonial stem cells in the mammalian testis after exposure to ionizing radiation. In this study, cytologically visible major chromasome aberrations, particularly translocations, are the chief indicators of damage and are readily demonstrated in the offspring of irradiated male mice.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00108-03 (RH-00494-03)	LATE EFFECTS OF THORIUM DIOXIDE RETENTION IN HUMANS	MURRAY L. JANOWER MASSACHUSETTS GENERAL HOSPITAL BOSTON, MASSACHUSETTS

Objectives: To establish the morbidity and mortality experience of a large group of patients who received Thorotrast for cerebral arteriography. All living patients will be subjected to intensive physical and laboratory examinations to detect the sequelae of their long-term radiation.

Significant Results: The health effects of chronic low dose internal emitter radiation has been explored in terms of the specific effects of the radioactive contrast material, Thorotrast, used previously in cerebral arteriographic examinations. The basic study plan has been that of a retrospective cohort study. In two of the three centers, 374 patients exposed to Thorotrast have been identified and a total of 316 controls have been selected. In addition, the exposed series has been augmented by 400 patients exposed to Thorotrast in a third center.

In cases of death, the information from the death certificate has been extracted. The history and current health status of living patients is recorded periodically in terms of a questionnaire. In addition, in one of the centers the living patients have been subjected to physical and laboratory examination.

It has proved possible to obtain a very high follow-up rate as far as mortality and questionnaire information is concerned. In the two centers where time has already permitted complete coverage, the follow-up information has been obtained in 662 of 690 patients. As of now, the typical follow-up time is twenty years. In addition, 70 patients have already been submitted to physical and laboratory examination.

Interim results are available for the two centers with controls. In these centers, a total of 28 malignancies have been identified, 16 in the Thorotrast cases and 12 in the controls. The malignancies in the Thorotrast cases generally have not been of the type associated with radiation exposure.

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EC-00108-03 (Continued)

There have been three cases of nonalcoholic cirrhosis of the liver, all in the Thorotrast series. Similar evidence of liver damage was also found in the liver function tests, particularly in the BSP and Alkaline Phosphatase tests. There was a very substantial excess of chromosome abnormalities in the Thorotrast patients. These included rings, dicentrics and fragments, abnormalities generally seen in irradiated cells. The chromosome studies permitted a very clear distinction between Thorotrast exposure and control patients. In only one of the Thorotrast patients did the breakage rate fall into the range of the control series, and this patient had had a very low dose of radiation.

Attempts to explore the dose response relationship were made both with respect to the liver function tests and the frequency of the chromosome abnormalities. In both areas, the number of patients with the laboratory data is still insufficient for adequate quantitative description; because of the small sample size, it has not been possible to determine how to best adjust the dose for body size, duration of exposure, etc. Evidence for a dose-response relationship was more definite for the chromosome abnormalities; in considering the frequency of chromosome breakage and number of abnormal cells, it appeared to be a linear one.

Radiation dosimetry measurements have been completed on the autopsy material from one patient. In addition to determining the inter- and intra-organ distribution of the nuclides, the total body content has been estimated from the material available. Significant findings include a much higher content of ^{228}Th in bone and bone marrow as well as a higher concentration than expected of all nuclides in the marrow. A further interesting finding was that there appeared to be considerably more movement of the short-lived nuclides of the thorium series within the body than had been expected. The total body radioactivity as measured from the autopsy material corresponded closely to that calculated from whole body counting. Further data of this type should add important information needed for accurate radiation dose estimation.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00109-15 (RH-00501-15)	MODIFICATION OF BACTERIAL CONJUGATION BY RADIATIONS	THOMAS H. WOOD UNIVERSITY OF PENNSYLVANIA PHILADELPHIA, PENNSYLVANIA

Objectives: Bacterial conjugation (union, chromosome transfer, genetic recombination and segregation) may be modified by radiation applied to either parent at various stages of the process. The objectives are two: to study in detail and breadth the various steps of conjugation and to examine the effects of radiation on chromosomes using a wide variety of endpoints for the detection of radiation damage and its repair.

Significant Results: Sexuality produces offspring (recombinants) which are more suited to their environment than either parent. Little is known of the details of genetic recombination--the process which mixes together the genetic determinants of two parents--and even less is known about how these processes can be modified and regulated. In the bacterium Escherichia coli conjugation consists of union between male and female cells; the transfer of a portion of the male chromosome into the female; the pairing of this male chromosomal fragment with its exact female analog; the substitution of a part of the male fragment for the corresponding part of the female chromosome (recombination); and the segregation of this new chromosome from other chromosomes of the female parent.

It has been found that these steps may be modified selectively by various chemical and physical agents, in particular, radiations. It has been possible to describe earlier observations with a simple mathematical model. A significant observation is that radiations have the same quantitative effect in preventing chromosome transfer as they have in modifying genetic recombination; this suggests that similar molecular mechanisms may be involved. By irradiating selectively either parent before mating it is possible to control the degree of utilization of chromosomal material from either parent--recombinants that are predominantly male or female in their genetic determinants may thus be prepared.

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EC-00109-15 (Continued)

Radiations applied to the fertilized female (the zygote) decrease the probability that nearby male genes will be incorporated simultaneously in recombinants; the further apart the male genes are, the larger this uncoupling effect. This result has been used to locate accurately nearby genes on the chromosome. This technique covers the region of gene separation for which mapping methods have not previously been available (from 4 to 40 genes). A new replica plating technique has been developed which permits more rapid and accurate genetic analyses of recombinant cells. This improvement is being used in conjunction with a mapping technique to study in detail chromosomal processes with the objective of understanding better how chromosomes interact and how these interactions are affected by various chemical and physical agents.

Publications: Wood, T. H., "Effects of Temperature, Agitation, and Donor Strain on Chromosome Transfer in Escherichia Coli K-12," J. Bacteriology, 96, 2077 (1968).

EC-00110-02 (RH-00506-02)

BIOCHEMICAL CHANGES IN SKIN INDUCED BY IRRADIATION

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HOUSTON, TEXAS

Objectives: A systematic investigation into the biochemical alterations produced by sunlight and ultraviolet light irradiation on human intact skin is to be conducted. In particular, careful attention will be given to biochemical modifications which may give some clue to the mechanisms *in re*.

1. The capacity of irradiation and environmental factors to injure skin with the ensuing production of erythema, inflammatory response, promotion of pigment formation, acceleration of degenerative changes and of premature aging.

2. The relationship of ultraviolet light to photosensitivity and its role in precipitating or aggravating systemic diseases such as lupus erythematosus, pellagra, porphyria and photosensitization phenomenon associated with certain drugs.

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EC-00110-02 (Continued)

3. The influence of sunlight and ultraviolet light on enzyme activity and the formation of substances with potent biochemical and physiological actions both beneficial (e.g., formation of Vitamin D) and deleterious (e.g., formation of pre-malignant and malignant skin morphology).

It is hoped that this investigation will contribute to a better understanding of photobiology.

Significant Results: The most significant finding is that exposure of the skin to sunlight or broad spectrum ultraviolet light brings about a profound reduction in the content and rate of formation of new fat, particularly cholesterol. This may be important; under some circumstances, the skin contributes significantly to the levels of cholesterol, related sterols and lipids in the blood and other tissues.

Though not generally realized, it may be possible to lower blood cholesterol and other lipid pools by exposing the skin to sunlight. The amount of exposure to sunlight may be a mixture of good and evil to man. Moderate amount of sunlight is essential for the production of vitamin D by the skin and may control levels of fat in the blood; excessive exposure to sunlight predisposes man to skin cancer and precocious aging. Work is now in progress to help elucidate and extend knowledge how ultraviolet light affects the biochemistry and physiology of skin.

Publications: None

EC-00111-01
(RH-00507-01)

THE VALUE OF RADIOPROTECTIVE COMPOUNDS

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MILWAUKEE, WISCONSIN

Objectives: To achieve the most desirable method of protecting laboratory animals against the lethal effect of ionizing radiation. To reach this goal the study is subdivided into eight specific aims of investigation. The study will include the

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EC-00111-01 (Continued)

pharmacology and toxicology of each promising radioprotective chemical. Enhancement of the protective effect will be investigated by using mixtures of new and existing radioprotective agents. Such an approach has been shown to be effective. Further enhancement of protective action will be investigated by combining pre-radiation administration of chemicals and post-radiation transplantation of bone marrow. Sites of chemical protection will be studied by combining partial body shielding and chemical administration. Repeated exposures to sublethal and supralethal doses of ionizing radiation will provide information on both the bodily recovery processes and on the phenomenon of radioresistance. The biological response of animals exposed to both 300 kVp X-ray and a linear accelerator source will be studied. These studies in animals will hopefully lead to finding effective radioprotective measures which can eventually be applied to man.

Significant Results: It is known that it is quite difficult to protect rats. Signs and symptoms of radiation injury in rats resemble closely to humans exposed to radiation. It has been found that a chemical mixture containing 5-hydroxytryptamine, 2-mercaptoethylamine and 2-aminoethylisothiouronium was highly effective in protecting rats. Following a radiation dose of 1100 R, all the animals without chemical protection died. When this chemical mixture was administered before exposure to the same radiation dose, all of the animals survived.

It has been known that it is most difficult to protect against the deleterious effects of neutron radiation. It was found that in mice, a combined treatment using pre-radiation administration of the above chemical mixture, a post-irradiation bone marrow transplantation, and supportive therapy with antibiotics gave satisfactory protective effect against otherwise totally lethal neutron exposure.

In an attempt to delineate the reason for some of the protective mechanisms of the highly effective chemical mixture, it has been indicated that one of the mechanisms of radiation protection in rats was the vaso-depressive effect of the chemical mixture.

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EC-00111-01 (Continued)

Investigations utilizing a chemical mixture consisting of 5-hydroxytryptamine creatinine sulfate (5 HT), 2-aminoethylisothiouronium bromide hydrobromide (AET), and 2-mercaptoethylamine hydrochloride (MEA) have been carried out in mice and rats. A triple treatment, including pre-irradiation protection by the chemical mixture, (2 μmoles of 5-HT, 7 μmoles of AET, and 25 μmoles of MEA injected intraperitoneally, 0.4 ml/mouse); post-irradiation administration of homologous bone marrow cells intravenously; and daily subcutaneous injections of streptomycin (5 mg in 0.5 ml saline) for 10 days after irradiation was used in CF No. 1/ANL mice exposed to single supralethal whole-body doses of fission neutrons (400 to 600 rads) or 250 kVp X-rays (900 to 1700 R). In the x-irradiated mice the multiple treatment elevated the $LD_{50(30)}$ from approximately 675 R to more than 1700 R, a dose reduction factor (DRF) in excess of 2.5. In comparison, the $LD_{50(30)}$ for neutron-exposed animals was increased by a factor of less than 1.3. When the pre-x-irradiation treatment with the chemical mixture was used alone, the $LD_{50(30)}$ of the mice was raised from 675 R to 1200 R or more (DRF of 1.8). With the same chemical mixture of $LD_{50(30)}$ of neutron-irradiated mice was increased less than 10 percent. These results indicate the value of a multiple approach in protecting against the deleterious effects of either neutron or x-irradiation. The data imply that greater injury and/or less recovery occurred in the neutron-exposed mice. In rats a chemical mixture consisting of 5 μmoles of 5-HT, 100 μmoles of AET, and 150 μmoles of MEA was shown to give protection against supralethal doses of x-irradiation. The $LD_{50(30)}$ for the chemically protected rats was 1580 R compared with a value of 860 R for control rats (DRF of 1.83). The protective effect of the chemical mixture was found to be greater than that of any of the components.

The pharmacological basis for the action of the 3 chemicals and the mixture was investigated. Carotid pressures were recorded in rats. A persistent vaso-depressive response occurred following 2 mg of 5-HT. No uniform or significant changes in blood pressure occurred following 28 mg of AET or 17 mg of MEA. When the radioprotective dose of the mixture was administered, there was a significant depressor response within 5 minutes. The blood pressure remained low during the interval corresponding to the

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time of radiation exposure. AET and MEA probably exert their action through the SH mechanism while the vaso-depressive response to 5-HT or the mixture may result in capillary stasis and tissue hypoxia.

Publications: None.

EC-00112-02 (RH-00520-02)

IN VIVO REPAIR MECHANISM IN IRRADIATED ANIMALS

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Objectives: To investigate systematically the mechanisms by which nonlethal doses of cyanide modify the actions of ionizing radiation in mammalian systems. The approach utilizes the kinetic patterns of cyanide-induced inhibition and recovery of tissue cytochrome oxidase in vivo and in vitro as a problem with which to explore the time relations and nature of the primary biochemical processes involved in the damaging action of ionizing radiations. It has recently been found that there exists a relationship between the degree of radioprotection by cyanide and the length of time cytochrome oxidase remains in the inhibited state. It is hoped that the proposed investigations will lead to new and improved chemical means for prophylactic and therapeutic treatment of radiation injury as well as new approaches to the enhancement of tissue radiosensitivity. If a functional relationship between cytochrome oxidase activity and radiation action is established, then it is hoped, in addition, that a new approach to cancer radiotherapy can be developed in which the radiosensitivity can be increased by unprecedented factors of ten or more prior to radiotherapy. Such an approach, involving the use of penicillamine for depleting copper, hence reducing cytochrome oxidase, has already yielded impressive results in the treatment of advanced melanoma in humans. Experimental studies along these lines are planned in order to confirm the validity of this approach.

Significant Results: Many drugs can protect animals given a lethal dose of irradiation from dying. How do these drugs work? The answer to this question will not only expedite the development of new and better drugs, but will also provide new approaches

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EC-00112-02 (Continued)

to a related problem--the selective killing of cancer cells by irradiation. A detailed investigation is being made on one of the most effective radiation-protective chemicals, namely cyanide. When a single non-harmful dose of cyanide is administered to rats or mice prior to their exposure to a radiation dose which kills 100 percent of the animals, all of the cyanide-treated animals survive. Why? It has been found that the protection depends on the time elapsed between the time the cyanide was given and the end of irradiation. For example, complete survival of mice given a 100 percent deadly dose of radiation was obtained even if 12-15 minutes elapsed, while with rats a 20-25 minute interval still permitted complete survival. The increased survival of cyanide-treated animals is accompanied by a substantial reduction in the number of damaged chromosomes--the cell structures carrying the hereditary material (DNA).

It has also been found that cyanide stops the manufacture of DNA and temporarily stops the activity of an enzyme, cytochrome oxidase, responsible for making energy available to cells. It turns out that the pattern of protection afforded by cyanide to irradiated animals parallels the time at which the enzyme begins to function again. Cyanide protects the animals by rendering their cells relatively resistant to the expression of radiation damage by stopping DNA synthesis and energy producing processes. At a critical stage, however, the enzyme activity resumes, making energy available to the cell so that the damage produced by radiation can be repaired.

Aside from pointing the way to more effective treatment of radiation sickness, investigations provide a rational biochemical basis for developing procedures to kill irradiated cancer cells more effectively.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00113-02 (RH-00521-02)	CANCER THERAPY BY INTERSTITIAL AND INTRACAVITARY RADIATION	BASIL S. HILARIS MEMORIAL HOSPITAL FOR CANCER AND ALLIED DISEASES NEW YORK, NEW YORK

Objectives: Interstitial and intracavitary radiation are of great importance in cancer management and there is no new modality in prospect which promises to replace either of them in the treatment of cancer. However, despite the generally accepted usefulness of interstitial and intracavitary radiation, there is considerable reluctance of most clinicians to use these techniques because of the radiation exposure problem.

In order to significantly decrease radiation exposure and at the same time achieve more effective interstitial and intracavitary radiation therapy, the development of new isotope sources and techniques is proposed. For interstitial radiation therapy the use of low energy seeds is proposed as a substitute for presently used high intensity radioisotopes. For intracavitary radiation therapy the use of "remote afterloading" with small high intensity sources moving during treatment is outlined. This technique promises to eliminate all radiation exposure to administering personnel and make intracavitary radiation as safe and simple as X-ray therapy. The major effort during this investigation will be placed on the problems of dosimetry and radiation exposure. Clinical evaluation of the beneficial effects as well as the side reactions of interstitial and intracavitary techniques and the radioisotopes involved will be carried out.

Significant Results: Efforts have been directed toward the improvement of techniques, development of new instruments and applicators for interstitial and intracavitary radiation, continuation of the clinical studies, and continuation of the medical physics studies concerned with the problems of dosimetry.

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EC-00113-02 (Continued)

Instrumentation: The iodine-125 seeds have become commercially available. Applicators were designed and constructed for intracavitary radiation by remote afterloading in cancer of the nasopharynx, vagina, esophagus, bladder, endometrium, and in intraoral tumors. An instrument was developed specifically for interstitial implantation of iodine-125 seeds; with minor modifications, it can be used with other gamma-emitting isotopes as well. It was displayed at the symposium "Frontiers for Interstitial Radiation Therapy" at Memorial Hospital in September 1969, which enjoyed widespread participation from here and abroad. It was also exhibited at the 55th meeting of the RSNA in Chicago, December 1969. On both occasions it was enthusiastically received. An improved model of the Remote Afterloader was built, which includes a control panel, automatic transmission of the sources, and higher activity cobalt 60 sources. The availability of time-saving computer services permits rapid computation of isodose curves, in the order to 10 minutes, which is essential for the proper dosimetric support for the Remote Afterloader.

Clinical Studies: A total of 386 interstitial implants and intracavitary applications were performed in 248 patients using iodine 125 seeds and the Remote Afterloader respectively.

Medical Physics Studies: Physics work was continued in three major areas: Physical measurements related to the determination of absorbed dose and the absolute calibration of activity, calibration procedures, and dose computation and data analysis by means of computer techniques.

Publications: None

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EC-00114-01 (RH-00523-01)	ABSORBED DOSE DUE TO INTERNAL RADIATION EMITTERS	GORDON L. BROWNELL MASSACHUSETTS GENERAL HOSPITAL BOSTON, MASSACHUSETTS

Objectives: The aim of this project is to investigate advanced methods of dose calculation and to compare the results of these calculations with experimental observations. Gamma-ray dose calculations are based principally on Monte Carlo methods of gamma-ray diffusion. Several existing programs will be extended to permit calculation of gamma-ray dose for a wide variety of geometrical conditions and for inhomogeneous media and interfaces.

The development of a special Monte Carlo program providing spectral information will permit a wider range of application than has been possible in the past.

The experimental verification of dose calculation methods has been largely lacking in the past. Experiments will be performed to confirm Monte Carlo calculations of dice in various configurations including nonhomogeneous media and media containing interfaces.

Significant Results: One of the major problems facing the medical user of radioisotopes is that of determining the amount of radiation delivered to various organs of the body due to the presence of the radioactive material. This project is aimed at simplifying these determinations for the general user, especially those who do not have ready access to a high speed computer. The end product will be a series of tables which can be utilized to make a reasonably accurate estimate for any case of interest using only simple arithmetic.

The basic technique used for this type of study is to conduct Monte Carlo studies for a number of various conditions. Even if previous Monte Carlo runs are used and the data resorted, this is time consuming, requires a high speed computer, and, if the source and/or target is small or they are distant from each other, may still be statistically meaningless. Methods have been investigated during the past year to increase the yield of usable data which can be extracted from the presently available

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EC-00114-01 (Continued)

Monte Carlo tapes. These techniques should greatly reduce the number of original histories required. At the same time the basic Monte Carlo program has been rewritten to make it compatible with the new computer which has been installed and to put it in a more universal language so that it can be more readily made available to other laboratories.

Another phase of the study which is well along is the use of specific absorbed fractions, obtained in the earlier Monte Carlo studies, to generate some of the information required for specific dose calculations.

Publications: None

EC-00115-03 (RH-00529-03)

MERCAPTOCYCLOPROPYLAMINES: RADIATION-PROTECTION AGENTS

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Objectives: A review of the literature suggests that chemical modification of the mercaptoethylamine structure continues to be worthwhile in the synthesis of new radioprotective agents; some highly active derivatives have been reported. This project concerns the synthesis and biological evaluation of structurally rigid compounds which represent molecular modifications of mercaptoethylamine and mercaptopropylamine.

These two compounds are among the most potent radioprotective agents and a study of compounds in which the NH_2 and SH groups are *cis* (i.e. held on the same side of the molecule) or *trans* (held on opposite sides of the molecule) should be complementary to the work of others concerning *in vivo* mechanism of action. For preparation and biological evaluation of such *cis* and *trans* isomers (compounds with the same formula, but different geometry of substituents) a cyclopropane ring system is desirable. Utilization of the 3-membered ring represents the smallest function for importing rigidity to the molecule and therefore enables synthesis of the *cis* and *trans* isomers most closely related to the parent mercaptoalkylamines.

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EC-00115-03 (Continued)

Significant Results: Two very important radiation-protective agents are beta-mercaptoethylamine (MEA) and gamma-mercaptopropylamine (MPA). During the past year, a study has been made of preparation of compounds (mercaptocyclopropylamines) related to MEA and MPA. These compounds have rigid structures and will be employed in the study of structural requirements for radiation-protective activity in animals. Studies on the chemistry of these unknown compounds have resulted in two publications. The thesis summarizes much of the work to date relative to the titled compounds. Two compounds have been submitted for biological evaluation. The Division of Medicinal Chemistry, Walter Reed Army Hospital, will evaluate these compounds in mice for radiation-protective activity; they will be assayed against normally lethal doses of ionizing radiation.

It is anticipated that the biological results will be of primary significance and will aid in directing future research in small ring mercapto-amine radiation-protective chemistry. The results should be of significance in elucidating the mechanism of action of these very important in vivo protectors against ionizing radiation. In the future, information obtained from these studies should be of value in studying radiation-damage and protection in humans. Presently, the synthetic chemistry which has evolved is also of significance and will be of value to a number of chemists working in related areas.

Successful synthesis of an acid unstable derivative of mercaptocyclopropyl-methylamine represents one of the major accomplishments during the past year. This compound is a rigid compound related to MPA. It is anticipated that the compound, which has been separated into the pure cis and trans isomers, will show significant radiation protective activity. Also it is expected that there will be a difference in potency depending upon whether the groups on the cyclopropane ring are cis or trans. Biological results obtained will be of major importance for the direction of future research. These results should be forthcoming within the next three or four months. Study is being continued to explore the chemistry of these, as well as a number of related small ring analogs of MEA and MPA.

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EC-00115-03 (Continued)

The synthesis of such small ring compounds requires the development of new reaction pathways and separation and purification techniques. Success has been made in developing a number of important synthetic routes in this area; a variety of physical methods have been worked out for the purification of the synthesized compounds in order that the pure compound may be submitted for biological evaluation. Particularly difficult was separation of pure cis and trans isomers. Methods have been developed for their separation, purification and structural identification. Research papers are being written on some of these results for publication in major chemical and biological journals.

Publications: No additional publications.

EC-00116-02 (RH-00530-02)

BEHAVIORAL EFFECTS OF LOW INTENSITY UHF RADIATION

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FAYETTEVILLE, ARKANSAS

Objectives: While the somatic effects of ultra-high-frequency (UHF) radio waves at high power and high frequency levels have been investigated extensively, the effects at low power and low frequency levels have largely been neglected. Investigations of the latter sort are needed since modern communication systems use low power and low frequency UHF levels.

Investigations of the following variables under conditions of low level UHF radiation will be conducted: (1) Behavioral effects: Although the author has already established that the behavior of rats is modified by low-level UHF, e.g., changes in activity, emotionality, and susceptibility to seizures, other possible UHF-induced behavioral changes (adaptability of behavior, learning, stress, as well as further measures of activity and emotionality will be investigated). (2) Power density levels and duration levels: Possible differential behavioral effects (a) under

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EC-00116-02 (Continued)

three levels of low power density (9, 5 and 1 mw/cm^2) and (b) after three durations of exposure (3, 6, 9 mos.) will be explored. (3) Neurophysiological substrates underlying behavioral effects: Although it has been assumed that the mechanism underlying UHF effects is heating of body tissue, recent evidence points to a particular neurohumoral system. The proposed drug studies and biochemical assays would provide information concerning the role of this system.

In summary, the broad objective of the proposed research is to obtain information concerning the effects of low-level UHF at the behavioral level and at the physiological level, as well as identifying the physical stimulus correlates associated with these levels.

Significant Results: Two experiments were carried out during FY 1969 in the continued effort to investigate the frequency, power, and duration parameters associated with the behavioral effects of low intensity UHF radiation. From the results of these two experiments it may be concluded (a) that extremely low levels of UHF radiation produce behavioral changes in albino rats, the most consistent change being a hypoactive response, and (b) that even though few behavioral changes occur at certain extremely low intensity levels, these changes become more apparent as duration of exposure is increased.

Publications: None.

EC-00117-02 (RH-00532-02)

IN SITU ASSAY OF RADIOACTIVITY FOR DOSE CALCULATIONS

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UNIVERSITY OF MIAMI
CORAL GABLES, FLORIDA

Objectives: To quantitate the spatial and temporal distribution of radiopharmaceuticals in man so that more reliable absorbed dose calculations can be made.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: None

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EC-00118-02 (RH-00536-02)	THERMOLUMINESCENCE OF RUBY AND IONIC CRYSTALS	WILLIAM G. BUCKMAN WESTERN KENTUCKY UNIVERSITY BOWLING GREEN, KENTUCKY

Objectives: Some materials' thermoluminescent properties have made them useful as radiation dosimeters which are complementary to and competitive with the film badge for personnel radiation dosimetry. The thermoluminescent yield and spectral emission of ruby and ionic crystals will be measured. The spectral emission dependence on temperature will be determined for luminescence produced by different modes of excitation.

Significant Results: During the past year, significant results pertaining to the ultraviolet excitation of sapphire and gamma irradiated lithium fluoride, the thermoluminescence of ruby and sapphire after X-irradiation, and the fluorescence spectral emission of sapphire as a function of temperature have been obtained.

The results from this research detail the response of sapphire to ultraviolet radiation. It concludes that sapphire is sensitive ($\sim$1u watt/cm^2), has a linear response for low radiation levels, has stable storage for at least eight days, and is virtually unaffected by normal room light. Since ultraviolet radiation has many technical applications and has many deleterious effects on man (conjuctivitis of the eye, skin cancer, and sunburn), steps are being taken to apply for a patent using sapphire as an ultraviolet detector.

Preliminary results on using gamma irradiated lithium fluoride as an ultraviolet detector have been obtained. This shows promise as an ultraviolet detector for germicidal lamps and further experiments are in progress.

The results of the thermoluminescence of ruby and sapphire have also been set out in detail. The sapphire is approximately as sensitive to X-rays as is the widely used Harshaw TLD-100 thermoluminescence powder. In addition, the stopping power response

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EC-00118-02 (Continued)

of sapphire is similar to bone, thus it can be used when one wishes to determine the absorbed X-ray energy in bone (such as in bone cancer treatment).

Interesting variations in the spectral emission of sapphire undergoing continuous X-irradiation have been observed. At 300°C, the chromium trace impurity R-lines and charge exchange region (6600-7100A°) predominate, while at 25°C the broad emission spectra near 3,000A° predominates. This indicates that similar effects might be observed for common luminescent materials used in radiology.

Publications: None.

EC-00119-02 (RH-00537-02)

NEURAL DETECTION OF IONIZING RADIATIONS

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OREGON STATE UNIVERSITY
CORVALLIS, OREGON

Objectives: There is reasonable evidence to indicate that the nervous system can respond to very small doses of ionizing radiations. The reaction is very similar to that induced by stimuli for which specific receptor systems have been established. No receptor is known for which ionizing radiation is the adequate stimulus. It is possible that radiation may be as effective as a physiological stimulus for several receptor systems. Evidence for this point of view, however, is limited and the available routes for the detection of ionizing radiations have not been established. Most of this work has been done in animal species that possess highly differentiated and complexly organized nervous systems. The purpose of this study is to examine the problem of biodetection in species of lower phyla with less differentiated systems. The study of mechanisms for detection in simpler systems should provide information that is instructive in the interpretation of this phenomenon in the more complex species. The manner in which representative organisms of several phyla are informed about their own exposure will be explored in order to establish the systems that might, under certain conditions, serve usefully as biodetectors for the presence of ionizing radiations.

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EC-00119-02 (Continued)

Significant Results: A study is being made of the physiological and behavioral reactions to low levels of irradiation. The extent to which prompt detection of radiation exposure is dependent on the type and degree of neural organization and specialization of receptors is being investigated systematically in several phyla of invertebrate organisms in order to determine the mechanisms leading to detection. It appears that the prompt detection of brief radiation exposures to X-rays does not require a highly organized nervous system. For example, experiments were made with a marine organism, the sea anemone, that possesses only a nerve net and no central nervous system or organized receptor organs. The study revealed that the anemone can detect the occurrence of X-ray exposure and will withdraw its tentacles within 200 seconds after 1 to 30 seconds of exposure to X-rays. The percent of subjects responding increases with the duration of exposure over the range tested. The latency to reaction varies inversely with dose rate over the dose range of 2 to 20 rad per second. The ability to detect radiations in this organism is not limited to energetic ionizing radiations since tentacle withdrawal also occurred with radiations of lesser photon energy in the far ultraviolet range. This is the first observation of a prompt behavioral reaction to ultraviolet radiation in the animal kingdom in organisms less specialized than the insects. Specialization of receptor and nervous systems occurs in forms higher than the anemones, and these forms are being studied to determine their relative efficiency in detecting the occurrence of a radiation exposure. Initial studies indicate that prompt reactions to brief bursts of X-rays and beta radiations can be found in representative species of several animal phyla, and that detection may occur through radiation excitation of more than one type of receptor system. Efficiency for X-ray detection appears to improve with the increasing differentiation and specialization of receptor systems.

Publications: None.

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EC-00120-01 (RH-00539-01)	HIGHLY ACTIVE STRONTIUM BINDERS	STANLEY C. SKORYNA McGILL UNIVERSITY MONTREAL, CANADA

Objectives: Alginates have been found to be the most potent available suppressors of radioactive strontium absorption. The extension of the peaceful use of atomic energy and the establishment of atomic power plants suggest that steps continue to be taken for possible accidental release of radiostrontium. The contribution of nuclear weapons testing presents the possibility of stratospheric increase of ^{90}strontium. The effectiveness of macromolecular bindings can be improved by chemical modifications; such modified products would be particularly useful in the treatment of acute poisoning cases. Furthermore, it seems possible to develop similar macromolecular binders for radium decontamination as indicated by our preliminary studies. Full understanding of the mechanisms of ion-exchange reactions by natural polyelectrolytes should be useful in the ultimate objective of synthesis of metal binders.

Although alginates and pectates are non-toxic and palatable and can be used directly in prevention of strontium absorption, considerable gaps remain in our knowledge of their mechanism of action and metabolism. The main objectives of this study are as follows: (1) to study mechanisms of action of alginates in order to identify the active component (2) to prepare chemical modifications of polyuronic acids and relate their chemical structure to their biological activity (3) to study the stereochemical configuration of alginates for the purpose of synthesis of new, active materials (4) to isolate and characterize the agent responsible for degradation of 30 percent of alginates in the gastrointestinal tract and (5) to study the chemical composition of the biodegradable and non-degradable moieties of the ingested alginate in order to develop model derivatives which can increase the effectiveness of treatment to 100 percent.

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EC-00120-01 (Continued)

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

EC-00121-01 (RH-00542-01)

RADIATION INDUCED FREE RADICALS AND RADICAL PAIRS

GRACE C. MOULTON
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TALLAHASSEE, FLORIDA

Objectives: The primary products produced by irradiating organic compounds of biological importance with X-rays, high speed electrons, thermal hydrogen atoms, or ultraviolet radiation at low temperatures will be investigated. The free radicals and radical pairs produced by the radiation will be detected and analyzed using electron spin resonance. There is in operation a sensitive X-band spectrometer capable of working from 77°K to room temperature, and shortly the capability will be extended to 4.2°K and below.

By working at low temperatures it is hoped to be able to trap the primary radicals in a greater percentage of cases and thereby gain a better understanding of the fundamental irradiation effects. Study will be made of single crystals mostly, since considerably more information can usually be obtained from a single crystal than powders or amorphous materials. Work will be done primarily with hydrogen bonded compounds since hydrogen bonding is so important in biological systems. Subsequent to the production and identification of the primary products, study will be made on the resulting products and the kinetics of the reaction when a sample is warmed slowly to room temperature. In addition to this, the same compound and related compounds will be irradiated with different kinds of radiation, at different dose rates, irradiated in vacuum or in the presence of oxygen, etc., in order to try to determine the importance of these variables in the radiation reactions. It is hoped that a thorough understanding of the

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EC-00121-01 (Continued)

fundamental mechanisms in free radical reactions in simple organic crystals should ultimately help in the construction of molecular models of free radical reactions in biological systems.

Significant Results: Most of the effort to date has been in the development of the electron nuclear double resonance (ENDOR) spectrometer. A new ENDOR microwave cavity has been designed and built to replace the cavity of the former electron spin resonance (ESR) spectrometer. This cavity fits inside a stainless steel variable temperature dewar capable of operating from 1.2°K to room temperature. The sample crystal mounted inside the cavity can be rotated 360° from outside the cavity and dewar. The magnet can rotate 360° around the dewar in a perpendicular plane. Inside the cavity is a single loop of wire for the ENDOR rf power. The rf signal is supplied by two oscillators whose frequency range is d.c. to 220 mc. The rf signal is amplitude modulated at 100 kHz, and then amplified by an IFI 10 watt power amplifier.

Work has resulted in complete ESR data at 77°K on single crystals of the amino acid dl-serine /$CH_2OHCH(NH_2)COOH$/ and deuterated dl-serine /$CH_2ODCH(ND_2)COOD$/ irradiated with 3 MeV X-rays. The principal radical in both is a triplet. It is an ionic radical which is primarily in a 2p state and exhibits hyperfine coupling to the nearby nitrogen atom. The lines are quite broad which means that there must be unresolved hyperfine couplings. A look will now be taken at the ENDOR spectra, which it is felt confident will resolve the hyperfine couplings which are not resolved in the ESR spectra.

Publications: None.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00122-02 (RH-00545-02)	REMOVAL OF AM-241 FROM HUMANS WITH DTPA	ALLEN BRODSKY UNIVERSITY OF PITTSBURGH PITTSBURGH, PENNSYLVANIA

Objectives: Data on the retention, translocation, and elimination of Pu-239 and Am-241 have been accumulated on several humans who were accidentally exposed to the inhalation of these radionuclides in the course of their employment. Since these radionuclides are potential carcinogens when present in bone and/or the lung, even in sub-microgram quantities, these patients have been treated with DTPA to increase excretion of these nuclides. It is planned to examine the data accumulated, and to continue further treatments and measurements on certain patients, in order to: (1) determine the most effective schedule of treatments for removal of these toxic agents and (2) develop an understanding and a quantitative theoretical model that can be used to predict appropriate dosages of DTPA and treatment schedules for future cases. Cases recently under treatment are providing unique opportunities for the in vivo measurements of these nuclides in various body compartments, and in excreta, as a function of time.

Significant Results: An individual who had for several years annealed and compressed compacts containing americium oxides, was counted in May 1967 and found to have a body burden of 1.8 μCi (about 2×10^{-7} of the total quantity processed). Infusions of 1 g DTPA in 250 ml saline were administered weekly from September 1967 to December 1968. After 18 days without treatment, 0.5 g DTPA administrations were given twice weekly from January 3 to April 8, 1969, followed by single 0.5 g DTPA treatments per week after April 8, 1969. In vivo counting data, and excretion analyses by gamma spectrometry of bulk samples, as well as HDEHP extracts, show that: 1 g DTPA per week continues to be effective (by at least a factor of five) in increasing excretion rates of systemic Am-241 and, by May 1969, had removed at least half the original bone burden and most of the liver burden. The remaining burden of about 1.0 μCi in March 1969 was being removed by 1 g DTPA per week at a rate of 0.0055 μCi per week, as measured by both external counting and analysis of total urinary excretion. This

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EC-00122-02 (Continued)

removal rate was the same for two 0.5 g DTPA treatments per week as for a single 1 g DTPA treatment per week. Recent single administrations of 0.5 g DTPA per week are showing only about 60 percent of the effectiveness obtained with 1 g DTPA per week. Another increase in DTPA treatment level is underway, and is expected to raise the Am excretion level again. Mathematical models will ultimately be fitted to the dynamic changes in organ content and excretion rates to obtain a general quantitative formulation of americium metabolism for use in internal dose estimation and treatment planning. An initial attempt to fit Healy's two-compartment (and two-parameter) model representing an "insoluble" Am pool slowly feeding in series to a systemic compartment, from which excretion rates may be represented by a power function, did not provide a good representation of the urinary excretion data for this case.

Publications: None

EC-00123-01 (RH-00551-01)

MACROMOLECULAR RADIATION PATHOLOGY

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ALBUQUERQUE, NEW MEXICO

Objectives: A study will be made of the fine structural and macromolecular changes induced in a variety of cells by ionizing radiation. The changes to be investigated are those which occur directly as a result of irradiation or appear within a few minutes after irradiation before the tissue is fixed for electron microscopy. It is planned to use a wide range of dosage and modalities of ionizing radiation, concentrating especially on gamma ray doses of the order of 10^4 to 10^5 rads.

Radiation damage to DNA molecules will be investigated by isolating DNA in thin films and visualization by electron microscopy (Kleinschmidt procedure).

Significant Results: The initial year of grant operation involved primarily the installation of an electron microscope, and establishing liaison with groups in

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EC-00123-01 (Continued)

this area having radiation equipment with high gamma ray dose rates. One radiation exposure of mice was done in July 1969 using the Kirtland Air Force Base, Albuquerque, New Mexico, flash X-ray unit, which was designed to simulate nuclear weapon bursts. This flash X-ray equipment delivers 10,000 rad of 10 MeV photons in 60 nanoseconds. Animals irradiated in this experiment were retrieved and tissue processed within two to five minutes after exposure.

Arrangement was made to obtain exposure time early in December 1969 on the electron prototype accelerator (EPA) in use at Los Alamos Scientific Laboratories (LASL), Los Alamos, New Mexico, in cooperation with the health physics division, Wright Langham, Ph. D., group leader. The EPA produces high energy electrons - these electron being accelerated on the crest of a radio-frequency wave.

This novel accelerator principle was invented by Dr. Louis Rosen of LASL and has exceeded expectations. The EPA is a prototype for the Los Alamos Meson Physics Facility (LAMPF) accelerator which is currently under construction in Los Alamos.

The LAMPF accelerator employs protons and will produce negative pimesons at rates aeequate for therapy of human neoplasms. Planning for the therapeutic potentiality of the "meson factory" is underway.

A voluminous production of 9 MeV gamma rays results from impinging the EPA output on a tantalum target. A dose rate of 4000 rad per second was achieved on the initial run with total body doses from 9000 to two million rads. Secondary problems such as the dangerous levels of ozone generated and dosimetry were solved by the LASL staff.

Samples of spleen, thymus, liver, kidney, cerebellum, and skeletal muscle were fixed for electron microscopy from each of the irradiated and from control mice. These samples have been embedded in epon and thin sections are presently being made.

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Circular and linear DNA preparations were irradiated in both exposures and are currently being used for Kleinschmidt determinations of molecular size and topology.

Tissue from the heavily irradiated animals is currently being analyzed, but preliminary results indicate marked changes in mitrochondrial christae and rough endoplasmic reticulum of animals exposed to the highest doses of radiation. Surprisingly, nuclei show only slight changes.

Publications: None.

EC-00125-01 (RH-00560-01)

STUDIES OF THERMOLUMINESCENT DOSIMETER CRYSTALS

THOMAS G. STOEBE
UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON

Objectives: The objective of this research is to determine the role of lattice defects in the thermoluminescent behavior of lithium fluoride single crystals. This includes:

1. The characterization of the defect structures of pure and doped, and of quenched and deformed LiF crystals as a function of time and temperature; and

2. The correlation of the behavior of these defect structures with thermoluminescent behavior.

This will provide the fundamental information necessary for the understanding and control of the structure-sensitive thermoluminescent properties of these crystals. The results will also be significant in that they will enable the further development of solid state radiation dosimetry for health physics applications.

Significant Results: The preliminary results of this project have indicated the significance of this work in understanding the properties of solid state radiation

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EC-00125-01 (Continued)

dosimeters. Thermoluminescent response has been found to vary markedly with heating temperature and cooling rate during annealing treatments. Along with the influence of impurities on response, these experiments indicate the importance of preparation procedures in determining the luminescence yield. The understanding and control of such parameters will assist greatly in the development of highly versatile lithium fluoride radiation dosimeters.

Publications: None.

EC-00126-02 (RH-00562-02)

EFFECT OF X-RAY SPECTRUMS ON RADIOGRAPHIC QUALITY

ROBERT J. SCHULZ
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BRONX, NEW YORK

Objectives: Almost all radiographic X-ray equipment is operated with 2.5 mm of aluminum filtration. This filtration allows a wide spectrum of X-rays to be incident upon the patient and the width of these spectra increases with kilovoltage. It appears reasonable, and preliminary experiments bear this out, that there are optimal X-ray spectra for each type of radiographic examination; optimal in the sense of minimum patient exposure and maximum radiographic quality.

The research objectives are to measure the X-ray spectra that result from the use of various high atomic number filters whose absorption characteristics markedly reduce the range of X-ray energies present in diagnostic X-ray beams. These "monochromatic" beams will then be evaluated in terms of the radiographic quality of radiographs they produce and the level of patient exposure.

Significant Results: On theoretical grounds it can be shown that for a specific radiographic examination, minimum patient exposure and maximum radiographic information are obtained with monoenergetic X-rays. In order to test the practicality of the

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theoretical results it is first necessary to produce X-ray spectra that contain a range of energies considerably narrower than the range obtained when the beam is filtered by aluminum. At the same time useful X-ray intensities must be maintained so that radiographs may be made in fractions of a second without overloading the X-ray tube.

The approach to this problem has been to use high atomic filters where the K-absorption edge of the filter material is matched to the voltage applied to the X-ray tube. By adjusting the high voltage to be 1.3 times the K absorption edge, X-ray spectra containing relatively narrow ranges of photon energies are obtained. Efforts to date have centered upon the construction of high atomic number filters, development of methods for measuring X-ray spectra and the collection of a library of X-ray spectra. To this end there are now seven "thin" X-ray spectra whose peak energies span the range of energies used in diagnostic radiology. These are obtained with the following filters and applied voltages:

Filter	Voltage	Filter	Voltage
Barium	55 Kvp	Gadolinium	75 Kvp
Cerium	60 Kvp	Holmium	80 Kvp
Neodymium	65 Kvp	Gold	100 Kvp
Samarium	70 Kvp		

Currently being measured is the transmission through water of these X-ray beams, and beams having 2 mm of aluminum filtration, in order to obtain a basis for comparison. Following this, an X-ray technique chart must be established and then studies will be started on radiographs of anatomical phantoms to test the premise upon which this study is based.

Publications: None.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00127-02 (RH-00563-02)	TV IMAGE STORAGE, ELECTRONIC MEMORIES, AND RADIOLOGY	WILLIAM B. MILLER, JR. EMORY UNIVERSITY SCHOOL OF MEDICINE ATLANTA, GEORGIA

Objectives: This research includes several investigations pertinent to recent developments in the fields of television image storage, electronic memory systems, and diagnostic roentgenography. These include determination of systems characteristics, adaptation of computer techniques to the production, storage and retrieval of images, and the performance of a series of controlled clinical trials to test operational hypotheses.

The major aim is to obtain the necessary fundamental data on this new X-ray television method of visualization, which will lead to new concepts of diagnostic radiology, with emphasis on significant dose reduction to the patient and environment.

Significant Results: The major purpose of this research continues to be proof of the applicability of "electronic radiography" to routine X-ray procedures for the purpose of X-ray exposure reduction and instantaneous image production. Concurrently with the clinical evaluations under way, research into the physical factors related to "electronic radiographic" image formation and storage being performed in the laboratory.

In the clinical application of "electronic radiography," the system has proven to have particular value in the performance of pediatric cystourethrography. In these cases any gonadal exposure is undesirable and must be kept to a minimum. A series of cases has been completed using X-ray factors essentially the same as those used for conventional fluoroscopy for several 1/30 second X-ray exposures. More than ample information was obtained for diagnostic interpretation with 3 to 11 seconds of X-ray exposure as compared with the 1 to 5 minutes ordinarily required.

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EC-00127-02 (Continued)

Renal biopsies are usually performed using intravenous urography and conventional fluoroscopy. Using "electronic radiography," the same number of diagnostic biopsies may be obtained, but with a decided reduction in exposure time. Approximately 30 separate X-ray images may be taken using conventional fluoroscopic technique with a total exposure time of 0.5 seconds.

For certain catheter positioning, while still using fluoroscopic kVp and mA, the exposure time can often be shortened from 5-10 seconds to less than 0.1 seconds.

The system has been used for two cases of fetal intrauterine transfusion, producing adequate X-ray imaging with greatly reduced equivalent exposure to the fetus. Hysterosalpingography has been performed with patient exposure being reduced to that equivalent to two seconds of conventional fluoroscopy.

During these intial clinical investigations the X-ray exposure was kept to a minimum and some deterioration in image quality was naturally present, the objective being to determine the minimum X-ray photon requirement for various types of diagnostic image information. In every instance, however, sufficient image information was obtained to accomplish the diagnostic aims.

Even with any increase in the X-ray photons that might be required for improved image quality during routine use, "electronic radiography" would still require much less X-ray exposure than conventional techniques.

The exposure reduction afforded through the use of this system of radiography has also permitted the University Regional Rehabilitation Research and Training Center to proceed with a research project for investigation of hip joint parameters in susceptible populations (cerebral palsied children), the objective being the study and prevention of hip dislocations which are highly disabling to physical function.

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Without the low X-ray exposure "electronic radiography" system a study of this type would be questionable due to the gonadal exposure possibilities using conventional radiographic technique.

Publications: None.

EC-00128-01 (RH-00567-01)

RENAL PHARMACOLOGY AND TOXICOLOGY OF FALLOUT NUCLIDES

B. V. RAMA SASTRY
VANDERBILT UNIVERSITY
NASHVILLE, TENNESSEE

Objectives: The renal excretion of various fallout radionuclides is probably achieved in part through their similarities and differences from ions of common biological occurrence. These differences and similarities between the fallout nuclides and the elements of biologic and toxicologic importance can be predicted from their relative positions in the periodic table. Further, these differences and similarities are useful to devise suitable regimen to increase the renal excretion and thereby decrease the toxicity of fallout nuclides: ^{90}Sr-^{90}Y, ^{137}Cs-^{137m}Ba, ^{140}Ba-^{140}La, ^{95}Zr-^{95}Nb and ^{103}Ru-^{103m}Rh. Therefore, this study is undertaken (1) to explore the renal handling of these nuclides by mechanisms and structures generally involved in the renal excretion of common ions of biologic and toxicologic importance, (2) to identify the biomolecules with which these elements are complexed for excretion in urine and (3) to study the effects of pharmacologic agents on their renal clearance. Among these nuclides all except ^{137}Cs are bone seekers, and their renal clearance can be influenced by pharmacological agents containing typical chelate structures (e.g., dicarboxylic acids, α-hydroxy carboxylic acids, α-aminoacids). The pharmacological agents of this group include chelating agents DTPA, BADE, etc. ^{137}Cs resembles potassium and its renal clearance can be influenced by agents which affect potassium metabolism (e.g., carbonic anhydrase inhibitors, maleate, etc.)

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EC-00128-01 (Continued)

The radionuclides ^{90}Sr and ^{137}Cs have long physical half-lives and they are fallout hazards. The other radionuclides have intermediate half-lives and contribute to the fallout hazard. Further, the stable nuclides of some of these nuclides (Zr, Nb, Ru) are used in alloys in chemical, aircraft and missile industries. Sufficient toxicological and pharmacological data must be obtained to ensure their safe handling.

Significant Results: The long lived cesium-137 (physical half-life 30 years) is of environmental and toxicological importance because of its ubiquitous presence in human populations, and in meat, milk, vegetables and other food materials due to atomic fallout. Further, its use by industry has increased in recent years. For example, about 0.4 megacuries of cesium-137 was shipped from the Oak Ridge National Laboratory between August 1946 and December 1963. In man and other mammals, renal excretion is the major route for the elimination of cesium-137 and the muscle mass is the critical organ for its retention. Therefore, information on the physiological mechanisms for renal elimination of cesium-137 and its retention by muscle and other soft tissues is essential before a successful regimen could be developed to enhance the excretion of cesium-137 by humans. In view of these considerations, efforts have been devoted to two specific aims: (1) for localizing the sites in the nephrons of dogs for reabsorption and secretion of cesium-137 in relation to those of potassium and rubidium and (2) for understanding the mechanisms of uptake, efflux and retention of cesium-137 in the rat tissues.

The clearance of cesium-137 was less than the glomerular filtration rate (creatininine clearance). Intravenous hypertonic mannitol increased cesium-137 clearance. Cesium-137 was not reabsorbed in the proximal tubule and not secreted in the distal tubule under mannitol diuresis. The secretory peak for cesium-137 in the distal tubule was observed at a site proximal to that of potassium or rubidium. Meralluride and triamterene were about 50 percent as effective in blocking the distal tubular secretion of cesium-137 as in the blocking of the secretion of potassium. All these results indicate that there are significant differences in the renal elimination of cesium-137 and potassium which could be explored further to enhance the clearance of cesium-137 without any influence on the potassium balance.

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EC-00128-01 (Continued)

Studies have been made of the uptake and efflux of cesium-137, rubidium-86 and potassium-42 by the isolated perfused rat liver and the rat hemidiaphragm to explain the retention of cesium-137 in the tissues. These studies gave the relative influx/efflux ratios of 1.00, 1.74 and 1.82 for potassium-42, rubidium-86 and cesium-137 respectively in the rat liver. The relative rates of uptake (rubidium-86 > cesium-137) and release (potassium-42 > rubidium-86 > cesium-137) of these radionuclides by the rat hemidiaphragm were similar to those obtained with the rat liver. Therefore, the slow efflux of cesium-137 is the major contributing factor for its build up of high concentrations in rat tissues.

Publications: None

EC-00129-01 (RH-00568-01)

TIME-RADIATION DOSE RELATIONSHIP TO BIOLOGIC DAMAGE

RICHARD L. WITCOFSKI
BOWMAN GRAY SCHOOL OF MEDICINE
WINSTON-SALEM, NORTH CAROLINA

Objectives: The objective of this research is to determine whether there is a time-dose relationship in the response of a biologic system to radiation delivered by clinically important radionuclides. The use of ever-shorter half-lived radionuclides in nuclear medicine is based on the concept that a somewhat larger dose of shortlived radionuclides can be given to patients than is possible with longer-lived radioisotopes, yielding both better diagnostic tests and less total radiation dose. This research is intended to determine whether there is a time-dose relationship in the biologic response such that the short life (or rapid dose-rate) actually produces more damage than the same dose of radiation delivered at a slower dose-rate. Usually, the potential hazards from internally administered radionuclides are compared directly with each other on the basis of absorbed dose (on a rad for rad basis). If a time-dose relationship exists, this would have to be considered in any comparison. This work would help establish whether a detrimental time-dose relationship is being overlooked in the widespread clinical use of short-lived radionuclides in humans.

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EC-00129-01 (Continued)

Significant Results: The purpose of these experiments is to help answer an important clinical question resulting from the increasing use of short-lived radionuclides in nuclear medicine. Is tissue damage from radiation greater, lesser, or the same, if the same radiation dose is given "instantaneously" by X-rays or at slower dose rates by the clinically important radionuclides, Gold-198 and Indium-113m? The capacity of rat liver to regenerate is the endpoint so a determination has been made of patterns of regeneration in untreated animals and the pattern of regeneration after graded doses of X-radiation. It was found that 200 rads of X-ray is sufficient to delay regeneration significantly. Now it must be determined if the same radiation dose delivered by the radionuclides over longer periods of time will produce the same biologic effect.

To do this it was necessary to determine the distribution of colloidal Gold-198 in rats, for this is a prerequisite for calculating radiation dose from gold to liver. Results so far indicate approximately 90 percent of injected gold is eventually taken up by the liver. Blood clearance and liver uptake studies showed nearly all of this occurred within five minutes after injection.

The relationship of liver weight to body weight, a necessary parameter in determining radiation dose to liver from the radiocolloids, has been established.

Publications: None.

EC-00130-01 (RH-00574-01) MEDICAL PHYSICS CONFERENCE

EDWARD W. WEBSTER
MASSACHUSETTS GENERAL HOSPITAL
BOSTON, MASSACHUSETTS

Objectives: This Conference is planned to bring together a national and international group of medical physicists to explore the present state of the art of medical physics, its problems and future trends. Emphasis will be placed on current research in medical

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nuclear physics, radiation dosimetry as it affects medical therapy and diagnosis, radiation protection in medical institutions, radiobiology as it concerns radiotherapy and radiation protection, and several other topics relating to the applications of physics in medicine including artificial limbs and organs, patient monitoring, biological measurements in hostile environments, and the medical uses of ultrasound, thermography and coherent light. In addition a primary purpose will be to review the important frontiers of medical physics for the benefit of U.S. specialists in this field by means of a series of symposia given by internationally recognized specialists.

Significant Results: Not applicable.

Publications: Abstract of papers - 2nd International Conference on Medical Physics.

EC-00131-01 (RH-00587-01)

SYMPOSIUM ON RADIONUCLIDES RADIATION DOSE AND EFFECTS

ROGER J. CLOUTIER
OAK RIDGE ASSOCIATED UNIVERSITIES
OAK RIDGE, TENNESSEE

Objectives: The objectives of this conference are to bring together the current concepts on internal dosimetry and present the methods now used to estimate internal radiation dose. Invited speakers, leaders in the field, will present various facets of the problem, exchange points of view, and define major disagreements that exist in this field. It is expected to generate some fruitful pathways for resolving some of the continuing questions on dosimetry and to suggest some innovations for research workers in the field. An important objective is to provide a current reference volume on the current state of this aspect of nuclear medicine, a resource that is definitely needed for practitioners and clinical investigators.

Significant Results: Not applicable.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00131-01 (Continued)	Publications: None	
EC-00132-01 (RH-00589-01)	RADIATION EFFECTS UPON NERVOUS SYSTEM BEHAVIOR	JOHN GARCIA RESEARCH FOUNDATION OF THE STATE UNIVERSITY OF NEW YORK ALBANY, NEW YORK

Objectives: Ionizing radiation produces: (a) immediate transient effects upon behavior and electrical activity of the brain, by stimulating the olfactory system and perhaps other peripheral receptors, (b) more enduring effects upon behavior which resemble the effects of noxious drugs and toxins, presumably produced by the products of energy absorption in the fluids and tissues of the body. This research is intended to elucidate the relevant physiological mechanisms, the methods of amelioration, and the general implications for psychobiology.

Significant Results: Previous research indicated that ionizing radiation produced two behavioral effects depending on the physiological site of action: (1) brief pulses of radiation directed at the olfactory area could be immediately detected by animals. (2) After exposure of the abdomen in particular, animals developed an aversion for food consumed prior to exposure.

First, recent research has demonstrated that rats can discriminate a single pulse (1.0-sec.) from a double pulse (two 0.25-sec. separated by 0.5-sec.) indicating that X-rays are acting directly upon the olfactory system since airborne products would be "smeared" by turbulence, making this fine discrimination impossible.

Second, it has been demonstrated that serum from irradiated donor rats produces toxic symptoms in recipient rats. These symptoms are identical to those seen in irradiated rats or rats injected with toxins and emetic drugs. Studies employing in vivo and

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00132-01 (Continued)

in vitro intestinal preparations indicate that serum from irradiated donors will cause immediate transient changes in intestinal motility. Preliminary fractionation studies indicate a polypeptide and a biogenic amine in serum of irradiated donors are producing toxic reactions.

Finally, a study is being made of the reactions of the intact animal to two kinds of environmental stress, namely peripheral pain as caused by shock and internal malaise as caused by toxins. Data indicate that animals adjust to peripheral pain using visual and auditory cues to guide motor avoidance responses, but adjust to toxic illness by utilizing olfactory and gustatory cues to change dietary selections. Preliminary brain lesion studies indicate that central mechanism of learning and memory for these two adaptive patterns are anatomically as well as functionally descrete.

Publications: Garcia, J., Green, K. F., McGowan, B. K., Ervin, F. R., "Onset of Bait-Shyness," Proceedings, 76th Annual Convention, APA (1968).

Garcia, J., McGowan, B. K., Ervin, F. R. and Koelling, R. A., "Cues: Their Relative Effectiveness As a Function of the Reinforcer," Science, 160, 794 (1968).

Garcia, J. and Ervin, F. R., "Gustatory-Visceral and Telereceptor-Cutaneous Conditioning -- Adaptation in Internal and External Mileus," Communications in Behavioral Biology, Part A, 1, 389 (1968).

EC-00133-01 (RH-00590-01)

ALTERATION OF MUTATION RATE IN MAMMALS

WALTER J. BURDETTE
UNIVERSITY OF TEXAS
HOUSTON, TEXAS

Objectives: In a previous study, it was found that the number of lethal mutations in Drosophila (fruit fly) may diminish after post-irradiation treatment with actinomycin D. This study will extend these experiments to mice, using the observed frequency of

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00133-01 (Continued)

dominant lethal chromosomes as the assay of mutation damage. This is an empirical investigation, since no attempt as basic understanding is being undertaken, with the object of finding a treatment that will reduce radiation effects.

Significant Results: It has been found that the mutation rate following X-irradiation can be reduced by the use of Puromycin, an inhibitor of protein synthesis. The significance of this finding is not only that protection against irradiation can be demonstrated but also that the agent reducing the number of mutations is an antibiotic that can be given to mammals, including humans, in effective doses without toxicity usually associated with such protection.

Based on previous observations that the lethal mutation rate on the X-chromosome in Drosophila is altered by administration of antibiotics, this study was designed to determine whether inhibitors of successive stages in protein synthesis alter the rate of mutation at different stages of spermatogenesis in mammals. One of the most efficient ways of measuring effects of irradiation in mammals is to determine the numbers of dominant lethals following irradiation, and this procedure has been used in these studies. A total dose of 175 roentgens was given to male mice, and the rate of mutations determined during four stages of spermatogenesis. The results show that Puromycin reduced the number of mutations significantly when given both before irradiation, and to a lesser extent, after irradiation. The effect occurs in the stage recovered between 14 and 19 days.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00134-01 (RH-00595-01)	NEW DECONTAMINATION TECHNIQUES FOR RADIUM-226	JOSEPH M. GENCO BATTELLE MEMORIAL INSTITUTE COLUMBUS, OHIO

Objectives: The objective of the proposed research is to develop new techniques for decontaminating surfaces that have become contaminated as the result of an accident or leak involving a radioactive source containing radium-226 salts or as the results of a direct spill of radium-226 salts.

Significant Results: Decontamination studies are being performed on the following surfaces: (1) concrete (painted and unpainted), (2) vinyl tile (waxed and unwaxed), (3) vinyl asbestos, (4) brick, (5) blacktop, (6) plywood (painted and unpainted), (7) metallic surfaces (stainless steel, aluminum, and lead), (8) wallboard (painted), (9) ceramic tile and (10) formica. Experimental decontamination studies are being carried out by contaminating representative 1 x 1 inch specimens of the surfaces mentioned above with finely powdered radium salt simulators. The simulants being used are the barium analogs of $RaCl_2$ and $RaSO_4$ tagged with Ba-133. Surface loadings of 1 to 10 $\mu g/cm^2$ are being used in the experiments. Contaminated surfaces are prepared by spreading a known volume of standard solutions of $BaCl_2$ and $BaSO_4$ on a known surface area and evaporating to dryness. A lead shielded Geiger-Mueller tube is being used to monitor the various surfaces after each decontamination step and to measure decontamination factors. Three broad classes of polymeric foams capable of forming solid foams are being investigated, namely, polyurenthanes, polyamines and epoxy-polyamides. The most promising class of materials appear to be the polyurethane foams. To function as effective solid foaming decontamination agents, these materials should possess the following desirable properties: (1) low surface tension and solid/liquid contact angle, (2) low density, (3) high cohesion, and (4) selective adhesion with radium salts but not with the contaminated surfaces.

Publications: None.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00135-01 (RH-00603-01)	QUANTITATIVE ORGAN VISUALIZATION IN NUCLEAR MEDICINE	ALBERT J. GILSON UNIVERSITY OF MIAMI CORAL GABLES, FLORIDA

Objectives: The objective of holding this Conference is to assemble a group of the world's experts on quantitative organ visualization in nuclear medicine so that the following questions and statements can be considered:

1. What instrumentation currently exists for quantitative organ visualization and what are the capabilities and limitations of these systems?

2. Will continuation of the development of this instrumentation lead to optimal systems for quantitative organ visualization, or must new instrumentation systems be developed?

3. Specify the characteristics of an optimal quantitative organ visualization system. Can a single system for all studies be developed?

4. Evaluate the problems associated with calibrating organ visualization systems.

5. Determine whether or not quantitative organ visualization systems are or will be of value in clinical nuclear medicine, or whether their usefulness is limited to research endeavors.

Along with individual experts discussing specified topics, panels of these experts will discuss and debate the merits of various methods of approaching and solving the problems associated with quantitative organ visualization.

After the Conference is completed the results will be published and widely disseminated so that the conclusions and information gained will be readily available to the scientific community.

Significant Results: Not applicable.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00136-01 (RH-00607-01)	RADIATION FACILITY FOR RESEARCH ON FOOD	WILLIAM B. ESSELEN UNIVERSITY OF MASSACHUSETTS AMHERST, MASSACHUSETTS

Objectives: During the past 12 years the University of Massachusetts has conducted research on irradiation of foods and other materials. Increasing needs for irradiation facilities have made it difficult for the grantees to depend on the use of local irradiation facilities and they wish to set up their own. The AEC has agreed to supply 50,000 curie Cobalt-60 source, building space is available in the department of Agricultural Engineering laboratories and the University has allocated $25,000 state funds toward the cost on estimated $50,000 apparatus to contain the Cobalt-60 source. The purpose of this project is to provide $25,000 in matching funds to purchase the apparatus required. As planned the departments of Food Science and Technology and of Agricultural Engineering would be prime users of the facility. However, the facility would also be available for use by other departments of the University, as well as nearby Amherst, Mt. Holyoke and Smith Colleges in order to provide joint use of this facility to maximum advantage.

Significant Results: Not applicable.

Publications: None.

EC-00190-06 (RH-00321-06)	STUDIES IN RADIATION PROTECTION	ROBERT R. KUNTZ UNIVERSITY OF MISSOURI COLUMBIA, MISSOURI

Objectives: To clarify the molecular mechanisms of radiation damage to a system and chemical protection from this damage. These studies, conducted on model systems are designed to provide information which may be used for a quantitative prediction

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00190-06 (Continued)

of the rate and mechanism by which damage will occur as a function of the molecular structure of the species exposed to the radiation. Such studies are expected to lead to development of more effective chemical protectors.

Significant Results: Studies of the molecular mechanism for decomposition of radiosensitive compounds of biological importance have been the subject of investigations during the past year.

The indirect attack route for the decomposition of amino acids by free radicals produced in the deposition of energy in radiolysis systems has been investigated using the methyl radical as a model attacking species. Results show that free radicals attack only the α-carbon on aliphatic amino acids and the side chain exerts only steric effects on the reaction rate.

The direct decomposition of cysteine by ultraviolet light simulates the environment of cysteine or a cysteine-like molecule which is excited directly by ionizing radiation. The yield of atomic hydrogen from this process has been determined and the rate of H-atom attack on the -SH group has been measured using a competition technique. This rate constant is nearly as large as that observed for the OH radical.

The mechanism by which H-atoms react with radiation protectors and radiation sensitizers has been measured in a radiolytic system as a function of pH. A significant mechanistic difference appears, in this mechanism, between thiols which act as protectors and those that act as sensitizers. These results are presently being confirmed for possible exploitation as a probe to determine the protective potential of a compound.

Publications: Volkert, W. A. and Kuntz, R. R., "The Reactions of Hydrogen Atoms in Aqueous Solutions. Some Amino Acids," J. Phys. Chem., 72, 3394 (1968).

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00199-04 (RH-00430-03)	CELLULAR LOCALIZATION OF XENON BY MICRORADIOGRAPHY	ROBERT J. SCHULZ ALBERT EINSTEIN COLLEGE OF MEDICINE NEW YORK, NEW YORK

Objectives: It has been shown in this laboratory that xenon gas, in the presence of oxygen, markedly potentiates the effects of X-irradiation. Because xenon is chemically inert, the site and mechanism of its potentiating action are of great importance in radiobiology. Using the methods of microradiography an attempt will be made to localize xenon at the intracellular level and to quantitate the amount of xenon present at specific sites.

Significant Results: It has been discovered that mammalian cells are sensitized to X-radiation when they are exposed to xenon gas at the time of irradiation. Specifically, HeLa cells exposed to xenon at a partial pressure of 3.5 atmospheres have a mean lethal dose one half that of cells exposed to air. This is opposite to earlier investigations by Hornsey et al and Evans et al that showed xenon to provide an anoxic type of protection to the bean root and the mouse respectively. No experiments connected with this project to date have resulted in an explanation for these differences in response. However, it has been demonstrated that similar sensitization is obtained in the Chinese hamster cell and it is likely that all mammalian cells will respond approximately the same way.

Studies have also been extended to the inert gases krypton and argon. These gases also sensitize HeLa cells to the effects of X-irradiation but much higher pressures are required. It has been observed that there is a direct correlation between the gas pressure required to achieve a given level of sensitization and the quantity of the gas dissolved in cellular lipids. It is expected that concurrent microradiographic studies of xenon cellular distributions will help to elucidate the mechanisms of inert gas sensitization.

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EC-00199-04 (Continued)

Microradiographic studies of normal HeLa cells are well under way. Although current techniques clearly show nuclear detail such as individual nucleoli, the cytoplasm remains largely unresolved because in the plated cell it is only a fraction of one micron thick. Modifications in the microradiographic apparatus will permit softer X-ray beams to be used and these should permit visualization of cytoplasmic structure.

Apparatus for localizing xenon within the HeLa cell has been completed and is currently being tested. This will require freezing the cells containing xenon to below the freezing point of xenon, -112°C, and then making the microradiography. Many technical problems have had to be overcome; however the first microradiographs of deep-frozen, hydrated cells are now in hand. These will be used as a reference for the first xenon localization studies.

Publications: No additional publications.

EC-00204-01 (RH-00509-01)

STUDIES ON ANTIRADIATION AGENTS

JOHN L. WONG
UNIVERSITY OF LOUISVILLE
LOUISVILLE, KENTUCKY

Objectives: The objectives of this project are:

1. To develop practical antiradiation agents which can provide long-lived protection to humans against ionizing radiation damage.

2. To study the mechanism of how antiradiation agents work at the physiological level.

Significant Results: The primary objective of the research proposed is to synthesize practical and effective antiradiation agents. No such compound has been reported to date. The compounds are designed on the basis of current theories of radiation protection. They contain a phenyluracil chromophore and a mercaptoethylamine moiety. Such

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00204-01 (Continued)

a molecule may provide protection against both direct and indirect actions of radiations by acting as an energy trap as well as a free radical scavenger, etc. Other variations of the structural feature are conceived to provide information on the mechanism of how the protective agents work at the physiological level. They may also define the criteria of an effective antiradiation drug, and such information will be helpful in future drug design. Several novel 5-aryl-6-methyluracils have been synthesized since the start of the project. They are in the process of being converted to the uracilmercaptoamines and biological testing will be conducted at that stage.

Publications: None.

RH-00302-05 LASER RADIATION IN PHOTOCHEMISTRY AND PHOTOBIOLOGY

ROBERT J. HUBER
NORTHEASTERN UNIVERSITY
BOSTON, MASSACHUSETTS

Objectives: To elucidate the nature of specific photochemical effects in biological damage caused by laser radiation. The technique of laser flash photolysis is used to study model chemical systems such as dyes and charge transfer complexes, as well as biologically active molecules. Laser-induced photochemical changes brought about by multi-photon absorption under conditions which preclude direct (one-photo) excitation are also under investigation.

Significant Results: During this period the laser flash apparatus has been modified for fast detection and for operation with frequency-doubling. The new photoelectric detection system has a time resolution of $\sim$5 nanoseconds and is suitable for measuring transients with lifetimes $\sim$100 nanoseconds. Multiphoton ruby laser experiments have been conducted with anthracene, and conventional flash photolysis studies have been performed with nitrogen heterocycles and flavonoid compounds.

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RH-00302-05 (Continued)

Preliminary experiments with some aromatic hydrocarbons have indicated that transients could be generated by multiphoton absorption and detected by optical absorption measurements. The results of further experiments will carefully purified samples imply that the transients observed originally may have arisen from impurities. Thus laser excitation (1 joule, 20 nanoseconds pulse, 6943 Å) of anthracene solutions under a variety of conditions revealed no transient absorption due to the triplet state. However, calculations based on the known value of the 2-photon capture cross-section (δ) for crystalline anthracene indicate that a measurable amount of the triplet state should be generated under these experimental conditions. The negative results permit a conclusion that the solution capture cross section (δ solution) has an upper limit of 2×10^{-2} δcrystal. This finding has just been independently confirmed by other investigators.

Conventional flash photolysis experiments were conducted with alloxazine, phenoxazine, and several flavonoid compounds in order to obtain data about their photochemical behavior which are needed for the evaluation of single photon and multiphoton flash experiments. These studies are still incomplete. Alloxazine produces a single transient in basic aqueous solution and two transients in ethanol. The latter are tentatively identified as the triplet state and a semiquinone-type radical. With phenoxazine, which was studied in several solvents, three transients have been characterized. These are the triplet state, the neutral radical resulting from loss of the nitrogen-bonded hydrogen atom, and the corresponding cation radical. The latter species appears to be produced by further photolysis of the triplet state. The flash photolysis of flavone and of isoflavone gives rise to single transients which have been identified as the corresponding triplet states. Under comparable conditions neither chromone nor xanthone produce transient absorption.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
RH-00470-02	COULTER COUNTER ASSAY OF BONE MARROW RADIATION INJURY	HUN LEE INSTITUTE OF MEDICAL SCIENCES SAN FRANCISCO, CALIFORNIA

Objectives: To develop a rapid screening test for the evaluation of radiation injury of bone marrow for individuals involved in a large nuclear accident. Previous studies on the radiation effect on bone marrow reveal that definite changes occur in the bone marrow cell-size distribution following irradiation. The Coulter counter is used as a tool for cell-size measurements in these studies.

Significant Results: The radiation dose-effect on the mouse blood leukocyte cell size distribution as indication of the extent of radiation injury of the animal was studied with a Coulter counter and a Particle Distribution Plotter. The results show that the non-irradiation control animals are unimodal in their leukocyte distribution. The distribution pattern changes rapidly after irradiation. The most outstanding change observed is the gradual emergence of a new peak, and the diminishing of the original peak. The two peaks locate at different parts of the distribution curve. The tendency of these changes is already clearly demonstrable at the 2-hour interval with animals exposed to 400 - 800 r. At the 4-hour interval, the bi-modal nature of the distribution curve becomes obvious with animals exposed to 600 - 800 r. At the 6-hour level, the distribution curve of the 200 r group becomes bi-modal with the new peak dominating, while those of the 400 - 800 r groups consist only of the new peak. The distribution pattern of the 100 r group remained uni-modal, consisting of the original peak. At the 18 and 24-hour intervals an unknown element (probably cell debris) emerges at the extreme left of the distribution curve for the whole five dose groups. This element dominates the whole picture while the original peak is at its lowest ebb with only one exception. The exception was made by the 100 r group at the 24-hour interval. In this case the original peak showed an unmistakable reappearance. The dose dependent nature of the changes are further demonstrated when the mean cell percentages of the two peaks are made into ratios with the percentage of cells in the new peak over that of the original peak.

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RH-00470-02 (Continued)

These results suggest that the technique should be further studied and explored as a survival test for man, as the technique is rapid, simple and adaptable for automatic large population screening work.

Publications: Lee, H. and Richards, V., "Evaluation of Radiation Injury of Bone Marrow with Electronic Particle Counting Device," Am. J. Clinical Pathology, 49 (1968).

RH-00512-01 RADIATION INDUCED CHROMOSOME DAMAGE AND CELL RESPONSE

FRANK J. SOBKOWSKI
UNIVERSITY OF SOUTHERN CALIFORNIA
LOS ANGELES, CALIFORNIA

Objectives: To obtain information on the patho-physiologic processes involved in the production of late somatic effects of ionizing radiation in vivo. Experiments are designed to simulate the temporal and physiologic conditions under which the late effects of radiation develop. The parameters to be studied include the incidence and types of radiation-induced chromosomal lesions, the kinetics of cellular and tissue regenerative phenomena and the histopathologic response of the irradiated tissue. It is hoped that the data from this project, when correlated, will provide information that not only is presently unavailable, but that will provide a base on which additional information may be developed so that an appreciation may be gained of the mechanisms underlying the pathologic processes involved in the production of the late somatic effects of radiation.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00041-06 (R77996-06)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	CHARLES E. BRECKINRIDGE, JR. UNIVERSITY OF ARKANSAS LITTLE ROCK, ARKANSAS

Objectives: This grant offers an academic program which will furnish the education and training requirements of persons interested in pursuing careers in Radiological Health. Strong emphasis is placed on measuring and controlling radiation in the environment and on investigating and developing methods for reducing radiation exposure.

EC-00042-05 (97983-05)	RADIOLOGICAL HEALTH SPECIALISTS TRAINING PROJECT	M. A. GREENFIELD UNIVERSITY OF CALIFORNIA LOS ANGELES, CALIFORNIA

Objectives: This program offers opportunities for advanced study and training in the general fields of radiation biology, radiation physics, and the clinical use of radioisotopes. Programs leading to a Master of Science degree and a Doctor of Philosophy degree in Medical Physics are open to qualified students who have majored in physics, chemistry or biology. The emphasis of this program is on the use of radiation and radioisotopes in the investigation of biological and medical problems, on the biological effects of radiation, on radiation measurements on earth and in space, and on reducing the radiation exposure to the public.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00043-08 (57992-08)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	JAMES G. KEREIAKES UNIVERSITY OF CINCINNATI CINCINNATI, OHIO

Objectives: This program provides a graduate radiation health specialist training curriculum. The trained personnel will be of the caliber capable of developing effective radiological health programs in Federal and State agencies, in industry and in medical centers. The radiological physics course of study emphasizes the physical problems related to the applications of ionizing radiation in clinical medicine. The students' thesis research for the masters degree consists of an approved project related to radiologic physics.

EC-00044-09 (87995-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	ADRIAN H. DAHL COLORADO STATE UNIVERSITY FORT COLLINS, COLORADO

Objectives: The radiation health--radiation biology--radiology program covers a broad area, including the effects of ionizing radiation on living tissues, the use of radioactive isotopes as tracers in biological studies, radiation physics, radiochemistry, radiology, and other similar fields. Strong programs of research are established in cellular and subcellular radiation biology, wildlife and domestic animal radioecology, practical health physics (such as (1) uptake of radon daughters in lungs of miners and (2) movement of polonium in a soil-plant-animal ecosystems), radiology and long-term radiation effects on beagles. The first year Master of Science degree programs are strongly oriented toward giving the students a broad background in Radiation Health in order to fill the need for these types of personnel in hospitals, state and federal public health departments, industry and universities.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00045-09 (27078-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	WILLIAM GROSS COLUMBIA UNIVERSITY NEW YORK, NEW YORK

Objectives: This program is aimed at the training of radiological physicists primarily in the application of radiation dosimetry in medical radiology, radiobiology, and radiation protection. It is also expected that some of the graduates will ultimately carry on independent research in radiological physics. This program attempts to give the student fundamental training plus the practical application of this training in dealing with patients and physicians.

EC-00046-09 (47013-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	HERBERT A. BEVIS UNIVERSITY OF FLORIDA (ENGR) GAINESVILLE, FLORIDA

Objectives: In this program all candidates for the master's or doctor's degree in the Department of Environmental Engineering are expected to have strength in traditional environmental engineering. The department offers many other courses on the various aspects of water supply, wastewater treatment, air pollution, water resources and environmental health. Several of these courses provide insight into the transport of radioactivity through man's environment.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00047-08 (47014-08)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	B. G. DUNAVANT UNIVERSITY OF FLORIDA (MEDICAL) GAINESVILLE, FLORIDA

Objectives: This program emphasizes hospital or medical radiation physics, radiobiology, and health physics. The program is located on the same campus as all the disciplines essential to the program and has excellent working relationships with all colleges and departments. Emphasis is placed on research as well as practical training.

EC-00048-08 (47049-08)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	F. W. CHAMBERS GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA

Objectives: In addition to the Engineering Experiment Station, there are three activities of particular interest to the program and include:

1. A modern radioisotopes and bioengineering laboratory for teaching and research in the biological sciences, sanitary engineering, nuclear engineering and physics. A 1 MeV Van de Graaff accelerator, a subcritical assembly and reactor simulator, and a 12,000 curie radiation source of Cs-137 are available.

2. The new Nuclear Research Center, containing laboratory facilities for teaching and research and a reactor similar to that located at the Brookhaven National Laboratory.

3. The Sanitary Engineering, Public Health, and Applied Biology Programs affording additional training and research in radiological health, sanitary biology and chemistry, radiobiology, and environmental radiation surveillance.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00049-08 (17999-08)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	DADE W. MOELLER HARVARD UNIVERSITY BOSTON, MASSACHUSETTS

Objectives: The radiological health program of the Harvard School of Public Health is designed to help meet the growing need for people who can offer leadership in the evaluation of radiation hazards and in coping with the many health problems associated with atomic and nuclear operations. The curriculum is strongly research oriented. Such activities currently emphasize reactor and nuclear facility safety, treatment and removal of airborne radioactive contaminants, evaluation of the biological effects of internal emitters, and studies on the mechanisms of radiation damage.

EC-00050-07 (67029-07)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	E. ROBERT BAUMAN IOWA STATE UNIVERSITY OF SCIENCES & TECHNOLOGY AMES, IOWA

Objectives: The Doctor of Philosophy degree in Sanitary Engineering (Radiological Health) is strongly research oriented. Students who qualify may pursue graduate study for this degree with minor work in nuclear science and general science, or biochemistry and biophysics, or statistics. The Master of Science Program in Sanitary Engineering is designed to provide the specialization needed by engineers and scientists to qualify them for work as radiation health specialists in sanitary engineering. Engineering courses are provided so the graduate can work as a sanitary engineer, and nuclear science courses are provided to give the graduate the required tools and understanding of the problems in this specialized field.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00051-09 (37042-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	RUSSELL H. MORGAN JOHNS HOPKINS UNIVERSITY BALTIMORE, MARYLAND

Objectives: The Department of Radiological Science provides a broad program of graduate education in both the theory and application of radiobiology, radiochemistry and nuclear medicine, radiation physics, and radiological health. The program is planned primarily for persons who wish to prepare for careers of teaching and research in the Radiological Sciences.

EC-00052-04 (67010-04)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	FRANK E. HOECKER UNIVERSITY OF KANSAS LAWRENCE, KANSAS

Objectives: To provide a course of study covering all basic principles and processes of interaction between ionizing radiation and matter. The program constitutes a broad and comprehensive coverage of radiation physics and radiation biology which is essential to a career in Radiological Health Physics.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00053-06 (47046-06)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	MAXWELL DAUER UNIVERSITY OF MIAMI CORAL GABLES, FLORIDA

Objectives: The program in radiological health is designed to train professional personnel in this highly specialized field of public health to assess and control radiation hazards resulting from the widespread use of nuclear energy in science and technology, x-rays, radium and other sources of ionizing radiation. Emphasis is placed on preparing candidates for service in public health agencies, medical facilities and institutions.

EC-00054-09 (57994-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	G. HOYT WHIPPLE UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN

Objectives: The purpose of these programs is to provide professionally capable persons who can fill responsible radiological health positions in universities, public health agencies, and industry. The interdisciplinary nature of the radiological health programs at the University of Michigan enables students to become familiar with both the pure research and radiological health aspects of major facilities which use sources of radiation.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00055-09 (67009-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	GAYLORD W. ANDERSON UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA

Objectives: 1. To produce graduates capable of thinking for themselves.

2. To integrate the broad spectrum of knowledge required of the Health Physicist into a logical pattern directed toward understanding the implications of and control methods associated with protection of man from radiation hazards.

3. To provide the training necessary to prepare students in the health sciences for responsible leadership in health agencies and health related industries.

4. To stimulate new ideas in both applied and basic research in Radiological Health.

EC-00056-09 (27089-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	MERRIL EISENBUD NEW YORK UNIVERSITY MEDICAL CENTER NEW YORK, NEW YORK

Objectives: The primary emphasis is on ionizing radiations but research involving other radiations, such as microwaves, is also underway. Many of the studies are undertaken through collaborative arrangements with municipal and State Health departments, and with the cooperation of industrial plants utilizing ionizing and other radiations. Much of the research and teaching program is designed around field problems.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00057-10 (37033-10)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	EMIL T. CHANLETT UNIVERSITY OF NORTH CAROLINA CHAPEL HILL, NORTH CAROLINA

Objectives: Plans of study in radiological health and safety are offered by combining the resources of North Carolina State University at Raleigh and the University of North Carolina at Chapel Hill. Students with prior preparation in physics whose preferences are reactor safety and health protection will enter North Carolina State at Raleigh in the School of Physical Sciences and Applied Mathematics or the Department of Nuclear Engineering or the School of Engineering. Students with preparation in health sciences whose preference is the comprehension of the radiological health sciences as a part of environmental control will enter the School of Public Health of the University of North Carolina at Chapel Hill in the Department of Environmental Sciences and Engineering.

EC-00058-07 (67024-07)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	JAMES P. VACIK NORTH DAKOTA STATE UNIVERSITY FARGO, NORTH DAKOTA

Ojbectives: The program is a 12-month interdisciplinary program providing a master's degree in radiation health physics. The university has a large Cs-137 calibration unit for training in instrument calibration and a large Co-60 irridation unit in a USDA facility available for training purposes. Field problems may be undertaken with area hospitals and a visitation with the Elk River Power Reactor will be undertaken.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00059-07 (57012-07)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	HERMAN CEMBER NORTHWESTERN UNIVERSITY EVANSTON, ILLINOIS

Objectives: To educate scientists and engineers in the role of radiation and nuclear energy in our developing technology and in the public health problems that arise as a consequence of the exploitation of radiation both as a tool and as an energy source. To technically train these scientists and engineers to become competent specialists in radiological health and enable them to cope with the new and unique health and safety problems that are associated with radiation technology.

EC-00060-07 (77983-07)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	GEORGE W. REID UNIVERSITY OF OKLAHOMA NORMAN, OKLAHOMA

Objectives: The curriculum and degree options provide for in-depth training in the application of the principles and practices of radiation protection to the public and the individual. Attention is focused on the analysis and evaluation techniques for problems with all types of radiation, nuclear and electronic products. Flexibility is available to develop the interest and background of the individual.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00061-06 (97996-06)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	E. DALE TROUT OREGON STATE UNIVERSITY CORVALLIS, OREGON

Objectives: The curriculum is designed on the basis that integration of related disciplines is the most effective way in establishing the capabilities of radiological health and radiological physics specialists. Close coordination is maintained among radiation biologists, radiation physicists, and public health personnel through frequent research conferences and seminars.

EC-00062-07 (27043-07)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	JOHN HALE UNIVERSITY OF PENNSYLVANIA PHILADELPHIA, PENNSYLVANIA

Objectives: A pivotal role in the radiation health of the general population will be fulfilled through at least three aspects: 1) the responsibility for direct influence on the optimum utilization of radiation producing equipment in the institution, as well as radiation safety problems in the use of radium and other radioactive isotopes; 2) research and development in new extensions of diagnostic x-ray apparatus and in the study and analysis of the quality and information content of the visual radiologic image to optimize further the ratio of information to patient dose; 3) teaching of the elements of radiological physics and radiation safety to the many professional and technical groups for whose education a medical center assumes responsibility.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00063-09 (27045-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	JOSEPH A. WATSON UNIVERSITY OF PITTSBURGH PITTSBURGH, PENNSYLVANIA

Objectives: Education of graduate students to function as operating personnel, research investigators and teachers in the recognition, prevention and management of health problems associated with radiation in: a) the nuclear industry worker population exposed to the occupational environment; b) the general population exposed to the aquatic and terrestrial environment; c) the patient population exposed to medical diagnostic and therapeutic applications of radiation; d) the clinical population in whom potential or actual radiation injury or radioactive contamination has occurred.

EC-00064-06 (57966-06)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	JOHN E. CHRISTIAN PURDUE UNIVERSITY LAFAYETTE, INDIANA

Objectives: The primary objective of the program is to train qualified personnel in the radiological health disciplines with the expectation that such individuals will later serve in radiation protection and control programs throughout the country.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00065-09 (27046-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	WILLIAM W. SHUSTER RENSSELAER POLYTECHNIC INSTITUTE TROY, NEW YORK

Objectives: The interdisciplinary program in Radiological Health is offered as part of the Environmental Engineering Curriculum. As a consequence, the students of Radiological Health are in direct contact with students and staff of all the cooperating departments of the Schools of Science and Engineering. The curriculum is intended to prepare well qualified students for useful careers of teaching, research or professional practice in areas related to radiological health activities.

EC-00066-09 (27088-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	A. JOEL KAPLOVSKY RUTGERS, THE STATE UNIVERSITY NEW BRUNSWICK, NEW JERSEY

Objectives: The program is designed to provide a broad education in the basic sciences upon which Radiological Health is built. The objectives are twofold: 1) train professional radiological health specialists who will be qualified for work in any area of the field, i.e., public health, industry, research laboratories, hospitals, universities, etc., and 2) provide a broad scientific introduction to students who wish to continue their studies to the Ph.D. in order to fill teaching and research positions associated with radiological health.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00067-07 (27042-07)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	CHARLES E. McGEE TEMPLE UNIVERSITY PHILADELPHIA, PENNSYLVANIA

Objectives: The course is designed specifically for the training of specialists, for positions in radiation protection and control programs in public health departments. Field experience is gained in the Radiation Safety office of Temple University, in local hospitals and industries, nuclear research facilities, and the City of Philadelphia, Department of Health.

EC-00068-06 (47012-06)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	ALVIN H. NIELSON UNIVERSITY OF TENNESSEE KNOXVILLE, TENNESSEE

Objectives: It is the aim of this program to provide graduate training to help meet an increasing national and international need (Public Health Agencies, government laboratories, industry, universities, hospitals, etc.) for persons broadly trained in Radiological Health physics. Because of the proximity of the University of Tennessee to the Oak Ridge National Laboratory, and because of the close cooperation which has grown up between the Department of Physics and the Health Physics Division, it is natural that the program described is strongly oriented in the direction of the physics of the interactions between ionizing radiation and matter, and that the degrees conferred are in physics.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00069-02 (77995-02)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	RICHARD D. NEFF TEXAS A & M UNIVERSITY COLLEGE STATION, TEXAS

Objectives: The program stresses the basic fundamentals in training Radiological Health Physicists at the professional level. The flexibility of the program allows specialization in one or more specific areas of the Radiation Health Physics field. In addition, students are brought into contact with the Health Physics support of research projects at Texas A & M's Nuclear Science Center pulsing reactor facility (TRIGA), the new 88-inch Cyclotron facility and numerous radio-isotope labs.

EC-00070-09 (77997-09)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	EARNEST F. GLOYNA UNIVERSITY OF TEXAS AUSTIN, TEXAS

Objectives: This program is designed to assist those students who wish to develop a basic understanding of radiological health problems that confront engineers working in environmental health engineering or other areas of engineering, such as nuclear engineering. Advanced study programs are available for those wishing to specialize in various areas of radiological health engineering. Supporting work in nuclear engineering, nuclear physics, radiochemistry, biochemistry, bioengineering, microbiology, zoology, etc., is available.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00071-08 (97970-08)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	KENNETH L. JACKSON UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

Objectives: Two options for the program leading to the Master of Science degree in Radiological Sciences are offered. The physical science option is designed to give the student advanced training in radiation physics and nuclear engineering, together with a broad background in biology, biophysics, chemistry, and other areas pertinent to radiological health. The biological science option is designed to give the student advanced training in the biological sciences, together with instruction in radiation physics, physical chemistry, radiochemistry, radiation biology, and other areas pertinent to radiological health. Both options include courses which will instruct the student in nuclear physics, radiation dosimetry and shielding, nuclear instrumentation, radiochemistry, environmental radiation hazards, radio-ecology, and radiation biology at the molecular, cellular, organ, and organism levels.

EC-00072-08 (17997-05)	RADIOLOGICAL HEALTH SPECIALIST TRAINING PROJECT	ERIC W. MOOD YALE UNIVERSITY NEW HAVEN, CONNECTICUT

Objectives: The purpose of the program is to provide radiological health specialists with substantial training in the principles of public health and biometry, in addition to intensive work in the several subspecialties of radiological health. This type of training will aid in the development of radiological health specialists who can work effectively as members of the public health team or as individuals on specialized projects.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00073-06 (47015-06)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	JAMES H. WALTERS CENTRAL FLORIDA JUNIOR COLLEGE OCALA, FLORIDA

Objectives: The Radiological Health Technology program is designed to train technicians for beginning employment in fields of work directly related to or associated with nuclear activity. Successful graduates are qualified to assist health physicists and act as environmental radiation monitors in locations as diversified as medical research laboratories, nuclear power plants, isotope manufacturing industries, and nuclear ship manufacturing plants.

EC-00074-04 (57993-04)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	JAMES G. KEREIAKES UNIVERSITY OF CINCINNATI CINCINNATI, OHIO

Objectives: Bachelor of Science: the objective of the program is to train nuclear medical technologists who can supervise and train other persons to become nuclear medicine technicians. Associate of Science: the objective is to train nuclear medicine technicians who can perform under supervision all of the current clinical diagnostic studies involving the use of radionuclides.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00075-06 (27047-06)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	JOSEPH F. MARCELLI HUDSON VALLEY COMMUNITY COLLEGE TROY, NEW YORK

Objectives: The three main objectives of this program are:

1. To offer an intensive two-year associate degree technical institute program in radiological health to supply technicians for employment in nuclear industry and government.

2. To foster an awareness on the part of the high school student of the need for technicians in nuclear industry and the benefits available to the student pursuing such a career.

3. To offer individual courses in nuclear physics, nuclear chemistry and radiobiology in our evening and extension division to permit area laboratory personnel to improve themselves while continuing their employment.

EC-00076-07 (17996-07)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	EDWARD B. VAN DUSEN LOWELL TECHNOLOGICAL INSTITUTE LOWELL, MASSACHUSETTS

Objectives: The program leading to the Associate in Science Degree in Radiological Health Technology is conducted through the Division of Evening Studies of Lowell Technological Institute with assistance from a USPHS training grant. The program is designed to train high school graduates for careers in radiological health and to provide retraining for persons working in the field. It is designed to produce technologists with a basic understanding of the theory and techniques required of senior level radiation technicians.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00077-06 (27044-06)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	GEORGE J. CROWE MANHATTAN COLLEGE BRONX, NEW YORK

Objectives: The Manhattan College Radiological Institute trains semi-professional personnel in a two-year tri-semester evening program. Students are employed during the day in radiological and non-radiological occupations. The program is designed to offer practical education of specialized study in radiation science. The courses provide realistic and intensive training on a broad basis so, in addition to developing demand skills, the participant will not be narrowed either in training or in the opportunity for further development and advancement. The courses of instruction provide the student with the basic concepts of radiation, its capabilities and potential hazards, basic analytical techniques and intensive training in radiological laboratory procedures as applied to biological, chemical and physical systems. The goal of the Institute is the practical education of personnel who will enter the fields of radiological health and science with a competency to immediately participate professionally short of planning experiments, data interpretation and critique.

EC-00078-07 (37040-07)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	ALAN K. ROECKLEIN MONTGOMERY COMMUNITY COLLEGE TAKOMA PARK, MARYLAND

Objectives: This program is designed primarily to prepare students for the increasing number of new occupations centered on the applications of nuclear energy and radioisotopes in industry and research. With an emphasis on the safety and control aspects of ionizing radiation and with a thorough introduction to the fundamentals of radiation physics and biology, completion of the program can lead to immediate employment as a Radiation Health Technician or Nuclear Science Aide.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00079-06 (27048-06)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	BEATRICE G. FEIBUS MURRELL DOBBINS AREA VOC. TECH. SCHOOL PHILADELPHIA, PENNSYLVANIA

Objectives: The radiological physicists are directly concerned with: a) problems of radiation control in hospitals and universities; b) teaching the fundamentals of radiological health to medical students and resident physicians; c) research and development programs which are essential to long-term advances in the most effective use of radiation in medicine.

EC-00080-06 (77998-06)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	DONALD W. BROWN OKLAHOMA STATE UNIVERSITY OF AGRICULTURE & APPLIED SCIENCE STILLWATER, OKLAHOMA

Objectives: This program is designed to supply qualified technicians for present and future employment in the field of nuclear science. The courses are arranged to give the student a balance of understanding and manual skills in a variety of applications of radioisotopes and radiation-producing devices. The graduate is expected to be able to work as a technician in radiation-related fields with brief on-the-job training.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00081-02 (47009-02)	RADIOLOGICAL HEALTH TECHNICIAN TRAINING PROJECT	A. H. NIELSEN UNIVERSITY OF TENNESSEE KNOXVILLE, TENNESSEE

Objectives: It is the aim of this program to provide undergraduate training in radiation protection to help meet the increasing national and international need for people competent in this field. Graduates from this program should be sufficiently well trained to be capable of managing the radiation protection of employees in the nuclear energy industries.

BUREAU OF SOLID WASTE MANAGEMENT

Functional Statement

Plans, conducts and promotes research, investigations, experiments, demonstrations, surveys and studies relating to the conduct of solid waste programs and development and application of new and improved methods of solid waste storage, collection and disposal. Develops new and improved methods of reducing the amount of solid waste requiring ultimate disposal through reuse, recycling and source reduction and provides technical and financial assistance to appropriate agencies and organizations in planning, developing and conducting solid waste management programs. Collects and provides, through publications and special reports, the results and professional analyses of research and technically oriented activities being conducted in the field of solid waste management. Encourages cooperative activities in solid waste management by the States and local governments and encourages interstate, intrastate and regional solid waste planning.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00033-02 (UI-00651-02)	DESIGN OF A WATER DISPOSABLE PACKAGING CONTAINER	SAMUEL F. HULBERT CLEMSON UNIVERSITY CLEMSON, SOUTH CAROLINA

Objectives: The principal objective of this project is to develop mathematical design relationships which will predict the behavior of a packaging container material (which can be processed to dissolve in water) under a variety of service conditions. (a) The kinetics of interaction between water soluble glasses and aqueous solutions will be studied. (b) The kinetics of interaction between "coated" water soluble glasses and corroding media will be studied. (c) The tensile strength, compressive strength, flexural strength, impact strength, fatigue strength, modulus of elasticity and hardness of the "coated" water soluble glasses will be observed before and after the corrosion tests. (d) The effect of the coatings and water soluble glasses upon the various biological systems of rabbits and rats will be investigated. This portion of the investigation is necessary to insure that the container materials developed are nondeleterious to health.

Significant Results: Soluble silicate glass compositions are readily coated by chemical vapor deposition processes. Metallic oxides derived from selected organic esters provide excellent coating materials for soluble glass substrates. The high vapor pressure and chemical stability of the mother liquid readily allows coatings to be produced by pyrolysis reactions at the heated substrate surface. Titanium oxide coatings are readily produced over a wide range of controlled conditions such as deposition temperature, time, carrier gas flow rate, reactant vapor concentration, substrate orientation, and others. The coatings produced can be amorphous or crystalline, depending upon conditions. These coatings are chemically stable, and form a chemical bond with the glass substrate. Silicon oxide glass coatings are produced under somewhat more restricted conditions; however, the coatings formed likewise possess excellent properties. The problem of residual stress in the coated samples is a greater hazard with SiO_2 coatings because of generally higher deposition.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00033-02 (Continued)

temperatures and a greater mismatch of thermal expansion coefficients.

The rendering of sodium silicate glass insoluble with H_2SO_4 in a displacement reaction involving participation by the sodium ions of the glass is an engineeringly feasible method for producing a water soluble packaging container. The H_2SO_4 treatment can be used to protect complicated shapes because the procedure is not critically sensitive to orientation of the substrate and distance from the input vapors. The resulting glass is transparent without any appreciable birefringence. The glass has an unusually high strength because of the compressive surface stresses resulting from the chemical treatment. The glass fragments similar to "safety" glass when mechanically ruptured are readily dissolved when broken.

Sodium silicate glasses in the composition range 1.0 $Na_2O \cdot 1.3\ SiO_2$ to 1.0 $Na_2O \cdot 1.6\ SiO_2$ possess adequate strength and ease of workability to be utilized as materials for construction of containers.

The engineering feasibility of water soluble packaging container consisting of water soluble sodium silicate glass superstructure with an enert barrier film deposited by either a chemical vapor deposition displacement reaction or pyrolysis has been demonstrated. The feasibility of ultimately applying the technology derived from this investigation to the solution of container waste control problems is bright, however, three basic questions have to be answered prior to the water soluble container becoming a reality: (1) The toxicology of the system, (2) the effect of the system on water quality, and (3) economic evaluation of processing procedures.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00034-02 (UI-00722-02)	UTILIZATION OF BROILER LITTER AS ANIMAL FEED	JOSEPH P. FONTENOT VIRGINIA POLYTECHNIC INSTITUTE BLACKSBURG, VIRGINIA

Objectives: To eliminate a major problem of disposal of an important solid waste product, broiler litter, by converting it into a useful product as animal feed. Palatability of sterilized broiler litter for cattle and sheep will be determined. Sterilized litter will be offered, singly and in combination with other feeds, free choice, cafeteria style, and palatability will be compared to conventional feeds. Organoleptic qualities of meat and feed lot performance as affected by feeding sterilized litter to cattle and sheep will be determined. Also, the meat will be analyzed for drug and pesticide residue.

Significant Results: The processing methods tested were autoclaving at 116° C under steam pressure of 1.06 kg./cm.^{2}, heating in a forced draft oven at 100 and 150° C, treating with beta-propiolactone (chemical sterilization) and fumigation with ethylene oxide for varying lengths of time. It was found that the only processing method which was consistently effective in sterilizing the litter was heating at 150° for four hours or longer. Autoclaving or treatment with the chemical sterilizing agents had no consistent effect on chemical composition of the litter. The use of dry heat at 100 or 150° C for four to 48 hours resulted in about a 20 percent decrease in crude protein. However, the protein level of the sterile samples was still very high, about 32 percent, which compares very favorably with the protein level of many commercial protein supplements for livestock.

There was considerable variation in chemical composition of samples obtained from different areas of Virginia, especially for crude protein, ash and gross energy, but all samples contained substantial nutrient levels. The variation in nutrient level would not preclude the use of poultry litter as animal feed, since certain other

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00034-02 (Continued)

feedstuffs on the market also show considerable variation.

The only pesticide residues detected in the waste were low levels of DDT and its breakdown products. Since DDT had not been used in any of the broiler houses from which the samples were obtained, the residues probably originated from the feed supplied the birds.

In an 80-day feeding experiment, sheep were fed diets containing up to 75 percent sterilized broiler litter. No gross symptoms of toxicological effects were observed. Feeding the litter had no consistent effect on various physiological parameters measured, such as daily urine volume, daily rectal temperatures, blood ammonia, blood urea, total red blood cell numbers, total and differential white blood cell numbers and urinary glucose, ketones, bilirubin, protein and occult blood. In detailed necropsies and studies of histological sections of various tissues, no adverse effects of feeding litter were evident.

Publications: None

EC-00161-03 (UI-00508-03)

CELLULOSE DEGRADATION IN COMPOSTING

JOHN S. JERIS
MANHATTAN COLLEGE
BRONX, NEW YORK

Objectives: To study the optimum conditions involved in cellulose decomposition of solid waste materials, the specific aims of which are:

1. To conduct pilot plant laboratory experiments to increase the rate of cellulose degradation in composting of municipal wastes by controlling the chemical and physical environmental factors affecting degradation rate.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00161-03 (Continued)

2. Attempt to evaluate the information gained in past investigations relating to the biochemistry of cellulose degradation.

3. To apply the pilot plant information to field composting units.

Significant Results: 1. The oxygen consumption rate obtained using a mixed refuse containing 60 to 70 percent paper is a factor of 10 greater than solid wastes containing nearly 100 percent paper. This difference was attributed to the biologically resistant nature of cellulose.

2. The oxygen consumption rate for continuously fed composters decreases significantly when operated at a material turnover rate greater than four days. A large percentage of paper is still visible in the waste.

3. High rates of biological stabilization are maintained by recycling composted material with fresh refuse. A recycle rate of 50 percent gave maximum results.

4. Maximum oxygen consumption rates were obtained at temperatures of 58 to 62^{o} C with the pH ranging from 8.0 to 8.5.

If the critical solid waste problem is to be solved, present methods of disposal must be reevaluated, modified and optimized. It is hoped that the results obtained in this investigation will lead to the optimization of the composting process. As this is the only process for solid waste handling which returns stabilized organic matter to the earth through the production of a useful end-product, the conservational aspect is emphasized.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00162-03 (UI-00516-03)	POLLUTION OF SUBSURFACE WATER BY SANITARY LANDFILL	A.A. FUNGAROLI DREXEL INSTITUTE OF TECHNOLOGY PHILADELPHIA, PENNSYLVANIA

Objectives: The establishment of criteria for choosing landfill sites and the development of computer models for use in landfill design and evaluation. Three long-range objectives are: (1) To provide means for predicting the quantitative movement of contaminants to ground water from present and proposed sanitary landfills; (2) to appraise design methods and remedial procedures for reducing any undesirable contaminant movement to within specified limits; (3) to develop hydrologic criteria for evaluating site suitability for sanitary landfill.

Significant Results: The results of this study have shown that a domestic sanitary landfill constructed using currently acceptable procedures will produce leachate in a humid environment. Leachate quantity and quality depend on the amount of water available for infiltration and the specific character of the landfill. In general, the leachate is highly polluting and will deteriorate the subsurface or surface water body into which it is discharged.

A computer model has been developed to analyze a specific landfill over its range of possible design parameters.

Publications: Steiner, R. L. and Fungaroli, A. A. "Analytical Procedures for Chemical Pollutants" - Research Project on Pollution of Subsurface Water by Sanitary Landfill. Drexel Institute of Technology. Series 1. No. 8. June 1968. 27 pages.

Fungaroli, A. A.; Steiner, R. L.; Emrich, G. H. and Remson, I. "Design of a Sanitary Landfill Field Experiment Installation"; Drexel Institute of Technology, Series 1. No. 10. November 1968, 32 pp.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00242-03 (UI-00510-03)	CHEMICAL TRANSFORMATION OF SOLID WASTES	VIRGIL H. FREED OREGON STATE UNIVERSITY CORVALLIS, OREGON

Objectives: To evaluate potential means of chemically converting waste components to products of value. The primary emphasis is placed on the study of cellulosic materials since cellulose is a common component of many wastes such as paper, refuse, straw, bark dust, etc.

Significant Results: 1. General: A. Completed a literature search for information about the chemical composition of solid wastes such as municipal refuse, straw, bark and tires.

B. Completed a general survey of the chemistry of solid waste components such as cellulose, lignins, waxes and oils, rubbers, etc.

2. Specific: A. Straw, rubber, paper, and bark were subjected to high pressure hydrogenation, using such catalysts as Raney nickel, iodine, hydrogen iodide, palladium, and tetrahydronapthalene. Also, reduction by the carbon monoxide-water reaction has been investigated. The oily products are being characterized. The oil obtained from bark apparently contains a high percentage of phenolic material. The oil from the various reactions would appear to have utility.

B. An evaluation of nitrogen and phosphorus enriched newspaper and straw as a soil additive was completed. Paper treated with urea and phosphoric acid at elevated temperatures appears to have value as a soil amendment.

C. Destructive distillation of straw, rubber, municipal refuse, and bark was accomplished. Prior mixing of waste with such materials as sulphuric acid, sodium hydroxide, or iron significantly affected the results of the distillation. The identification of the liquid and gaseous products of distillation is continuing.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00242-03 (Continued)

D. The application of cellulose chemistry to wastes to produce a useful product was accomplished. Newspaper and straw have been used as a raw material in the production of cellulose acetate. This material can be pressed into a solid plastic form at elevated temperature and pressure.

E. The combination of ground solid wastes and plastic can be pressed into sheets that may be useful as construction material.

Publications: No additional publications.

EC-00243-03 (UI-00511-03)

CONSERVATION OF RESOURCES IN MUNICIPAL WASTE

CLARENCE E. SCARSBROOK
AUBURN UNIVERSITY
AUBURN, ALABAMA

Objectives: To compare the relative effects of processed garbage, sawdust and peat during the establishment of a grass cover using several different types of grasses. Evaluation of the following: (a) effect of the inclusion of processed garbage in a hydroseeding operation; (b) effect of the inclusion of processed garbage and activated sludge with peat as a mulching compound.

Significant Results: Garbage compost added at the rate of 100 tons per acre to soils ranging in texture from loamy sands to clays ameliorated the toxicity to crops of certain herbicides but had no effect on others. Fluometuron and trifluralin (each at 30 lb/A) were toxic to cotton without compost additions, however, with compost there was no toxic effect of the herbicides on cotton. Compost did not reduce the toxicity of bromacil (50 lb/A), picloram (30 lb/A) or simazine (30 lb/A).

Garbage composts when first applied to soils were often toxic to seedlings but there was little injury when the soil was reseeded 4-6 weeks after application of compost.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00243-03 (Continued)

The two garbage composts used as received from the supplier both require large amounts of N and P for plant growth; however as the compost aged it becomes more satisfactory as a medium for plant growth.

The composts compare favorably with hay and pine straw as a mulch for erosion control.

The garbage composts used do not appear promising as a part of the growth medium for ornamentals but may be satisfactory as mulches.

Publications: Scarsbrook, Clarence E. et al. "Conservation of Resources in Municipal Waste." Progress Report for period: April 1, 1968 to March 31, 1969. 115 pp. Auburn University.

EC-00244-02 (UI-00512-02)

DISPOSAL OF DAIRY CATTLE WASTES BY AEROBIC DIGESTION

ALVIN C. DALE
PURDUE RESEARCH FOUNDATION
LAFAYETTE, INDIANA

Objectives: The overall objective of this research is to develop complete aerobic digestion systems for the disposal of solid wastes from chickens, cattle and swine. The more specific objectives are as follows:

1. To determine the physical and chemical characteristics of the livestock waste and the material that must be removed to permit good digestion by aeration.

2. To determine preliminary treatment needed as found in objective 1 and to develop methods of accomplishing this treatment for livestock waste disposal systems.

3. To determine daily or continuous loading rates of the solid wastes that will permit satisfactory (complete) biological digestion.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00244-02 (Continued)

4. To determine information on the biological oxidation rate and completeness of digestion of the livestock wastes as related to the temperature of the aerobic chamber.

5. To adapt some presently known oxygenation method to livestock production units.

6. To develop methods of handling the degraded solids and the reuse of the effluent for cleaning animal units and return to the digestion chamber.

7. To collect basic information on the characteristics of the livestock wastes as related to feed stuff, antibiotics, etc.

Significant Results: Possibly the most significant development of this project has been the phase on "the disposal of dairy cattle wastes by aerated lagoons and irrigation." Following laboratory studies, a system was developed on the digestion of dairy cattle manure and the control of odors by mechanical aeration.

Demonstration shows that such a system has a number of advantages as follows:

1. The system is odorless.
2. The lagoon provides a place that can take the wastes produced at all times.
3. The method of handling the wastes is simple.
4. Labor requirements are low.
5. Good reductions in BOD, COD and volatile solids are obtainable.
6. Crops respond rapidly to the nutrient laden effluent.
7. Suspended solids are removed with the irrigation system and desludging is seldom required.
8. There is an apparent lack of fly and mosquito breeding in such a system.
9. The cost is moderate.

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The system appears to work so well that is is being copied by a number of dairy and other livestock operations.

Laboratory studies of decomposition indicate that it is possible to decompose up to 70 percent of the volatile solids in dairy cattle manures under given conditions. However, to accomplish this level of digestion, the large fibers and stems from undigested feed must be macerated or ground to a moderately fine level.

Publications: None

EC-00245-03 (UI-00514-03)

LIVESTOCK WASTE MANAGEMENT AND SANITATION

DONALD L. DAY
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

Objectives: To study biological treatment methods of beef and dairy cattle manure. To field test a completely mixed aerobic oxidation ditch as a method of treament for manure. The system consists of an oxidation ditch beneath self-cleaning slotted floors in a confinement livestock building. Mixed liquor from the oxidation ditch flows by gravity to an aerobic lagoon (oxidation pond or aerated lagoon) having a fluctuating depth. Surplus water and solids can be irrigated from the lagoon onto fields at a time that is convenient to the operator. This results in a system that is very low in labor and odors from animal to field.

Significant Results: The development of a waste management system that very nearly satisfies the criteria of low labor, low odors, prevention of stream pollution, simple

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to operate, and economically feasible.

Results have shown the operating criteria of the in-the-building oxidation ditch to be: (a) a ditch liquid volume of 30 cu. ft. per lb. of daily BOD_5. Note the loading BOD_5 is in a very concentrated form (30,000 to 50,000 Mg/L instead of 300 to 500 Mg/L as in municipal oxidation ditches).(b) The liquid depth is shallow, usually less than 2 ft. to keep the solids suspended. (c) The aeration rotor should have an oxgenation capacity (as measured in clean water at standard conditions) twice that of the daily BOD_5 loading.

After coming to equilibrium, the ditch mixed liquor BOD_5 will typically be 3,000 to 5,000 Mg/L resulting in a 90 percent reduction of the oxygen demand of the livestock manure. Also, total volatile solids are reduced about 50 percent. However, the effluent, even if the settleable solids were removed from the supernatant, is not suitable for direct discharge into a stream because of the color (reddish brown) and the mineral content. Thus the reason for the nonoverflow aerobic lagoon and the irrigation system.

There are many livestock producers adopting the waste treatment system described above and at least two companies are manufacturing aeration rotors specifically for livestock oxidation ditches. The method does of course have inherent costs, the greatest being the rotor operating power cost. However, this may be an attractive alternative to the producer faced with odor nuisance or stream pollution complaints.

Publications: Day, D. L. and Converse, J. C. "Oxidation Ditch for Swine Waste." Engineering Foundation Research Conference. July 24-28, 1967. University School. Milwaukee, Wisconsin. Conference Preprint No. E-5.

Dale, A. C. and Day, D. L. "Some Aerobic Decomposition Properties of Dairy Cattle Manure." Transactions of the ASAE. Vol. 10. No. 4. pp 546-547 and 548. 1967. University of Illinois.

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EC-00245-03 (Continued)

Day, D. L., Converse, J. C. and Jones, D. D., "Rotor Aeration of Swine Wastes." Illinois Research, pp 16-17, (Spring 1968), University of Illinois.

Day, D. L., "Oxidation Ditches Combine Well with Slotted Floor Hog Setups." Prairie Farmer, Engineering on the Farm, 140, No. 2,(Feb. 3, 1968), University of Illinois.

Day, D. L., "Annual Report of Cooperative Regional Projects-Illinois Agricultural Experiment Station," Report, (10-5-67), 5 pages, University of Illinois.

Day, D. L., "Research Study Tour," Progress Report, Project 10-375, Tour of research stations in Europe dealing with livestock housing and waste treatment. (Summer 1967), 8 pages, University of Illinois, Urbana.

EC-00246-06 (UI-00515-06)

INTEGRATED CONTROL OF THE HOUSE FLY

RICHARD C. AXTELL
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

Objectives: 1. To determine the factors influencing phoresy and predation by manure-inhabiting mites, with emphasis on the sensory behavior of Macrochelidae.

2. To determine the effects of insecticides and application methods on the natural enemies of the house fly, with emphasis on the manure-inhabiting predacious mites.

Knowledge in these areas will be used to design an integrated program for control of house fly breeding in domestic animal manure.

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EC-00246-06 (Continued)

Significant Results: A successful fly control program for caged-poultry operations has been developed. This program integrates the selective use of insecticides with procedures to encourage the maximum populations of biological control agents, especially manure-inhabiting predaceous mites. The advantage of this integrated fly control program over conventional control practices, especially larvicidal treatment of the manure has been demonstrated. The integrated control program requires fewer applications of insecticides which reduces hazards of application and residues, rate of resistance development, and cost of operation. The program requires only one manure removal per year and thereby reduces labor cost and problems of manure handling and disposal.

The effectiveness of the integrated fly control program can be increased by bolstering the population of biological control agents. This prospect is encouraging due to the discovery of a new species of parasited mite which destroys fly eggs and larvae at a much greater rate than the previously known species of mites. It is now possible to rear large numbers of three species of mites which complement each other in their predatory behavior against the eggs and larvae of the house fly.

Publications: No additional publications.

EC-00248-05 (UI-00517-05)

SMOKELESS INCINERATION OF BULKY MUNICIPAL REFUSE

ELMER R. KAISER
NEW YORK UNIVERSITY
NEW YORK, NEW YORK

Objectives: The main objective is to establish engineering design data for the handling, charging, and smokeless burning of oversized burnable wastes. The data are to be useful to municipalities, consulting engineers, incinerator builders and others in creating incinerators that meet modern requirements for low air pollution.

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EC-00248-05 (Continued)

Secondary objectives are data on refuse composition, bulk density, and calorific values; and data on residue, fly ash concentrations in the flue gas; locations for overfire air jets for the combustion of hydrocarbons.

The tests on the batch-fed prototype furnace are to be completed and reported, after which other available furnaces are to be observed while burning oversized refuse.

Significant Results: The project has been concerned with the research and development of relatively simple incinerators for burning oversized wastes without prior shredding or sorting. Among wastes that are too large or slow burning for conventional incinerators are tree stumps, logs, branches, demolition lumber and timber, furniture, mattresses, tires, boxes pallets and crates.

The project proved the feasibility of two-stage combustion for producing smokeless stack gas despite the presence of tires, plastics, paints and other smoke producing elements in the refuse. The pilot furnace was charged by tractor, by pushing the debris onto the furnace floor at ground level.

A full-scale furnace of the above type operated by the City of Norwalk, Connecticut, was given a two-day test at full rating. In addition to the above types of refuse, which burned satisfactorily, large quantities of leaves were burned as well. The test demonstrated smokeless operation with two-stage combustion, but also proved the advisability of air admission through the furnace floor for high burnout.

The validity of the project findings was demonstrated in the initial runs of the City of Stamford, Connecticut, multi-purpose incinerator.

Publications: Kaiser, E. R., "The Incineration of Bulky Refuse II." Proceedings of 1968 Incinerator Conf. pp 129-135, New York University, Bronx, New York.

Kaiser, E. R., "Thermal Processes for Refuse Reduction," Abstract presented at American Public Works Assn., Institute for Solid Wastes, Annual Meeting held in Boston, Mass., (Oct. 1-5, 1967), 11 pages, New York University.

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EC-00249-03 (UI-00520-03)	MICROBIOLOGY AND ACID PRODUCTION IN SANITARY LANDFILLS	JERRY C. BURCHINAL WEST VIRGINIA UNIVERSITY MORGANTOWN, WEST VIRGINIA

Objectives: To determine how decomposition of sanitary landfills may be speeded up or slowed down through the judicious use of nitrogen, phosphorous and potassium, under varying conditions of moisture, temperature and compaction. To study the correlation of different organic acids and to establish the initial sources of these acids. An additional aim will be to correlate the above with gas production, quality, quantity, and volume produced per unit of refuse. Pure cultures of bacteria plus those from fresh household refuse and from existing sanitary landfills will be used to seed synthetic refuse.

Significant Results: Although all studies were laboratory studies the refuse was either of the type that would normally be found in a sanitary landfill or was actually obtained from a sanitary landfill and brought to the laboratory.

Analyses of samples collected from an actual sanitary landfill yielded moisture content ranging from 19 to 46.7 percent. Total nitrogen ranged from 0.72 to 1.21 percent with an average of 0.88 percent. Combustibles were 945 milligrams per gram. The average phosphorous content was 0.4 percent and that of potassium was 0.3 percent. Of the three elements nitrogen appeared to be the limiting one. More aerobic bacteria were found with added nitrogen at higher temperatures and moisture content whereas more anaerobic bacteria were found with added nitrogen at lower temperatures and moisture contents.

In the study of sequential acid and gas production in decomposing refuse it was determined that acetic and n-butyric acids were produced simultaneously shortly after decomposition commenced. Propionic, iso-butyric, iso-valeric, iso-caproic and n-caproic acids were then progressively produced but in lesser amounts than acetic and n-butyric. Moisture played a significant role in acid production there being in some cases five times more acid produced at 80 percent than at 45 percent. Maximum acid accumulations occurred within 21 to 49 days after the beginning of decomposition. Gas analysis showed mainly carbon dioxide, hydrogen, nitrogen and traces of methane.

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The succession of microorganisms in decomposing refuse has been the most difficult part of the research because of the overgrowth of the faster growing organisms over the slower. The Clostridia group of bacteria, E. Coli and some Bacilli have been identified and associated with organic acid formation.

Publications: Burchinal, Jerry C. "Microbiology and Acid Production in Sanitary Landfills." An Interim Report. 23 pp. West Virginia University.

EC-00250-03 (UI-00521-03)

EFFECTS OF GARBAGE COMPOST ON SOIL PROCESSES

CHARLES C. HORTENSTINE
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

Objectives: To study the effects of adding garbage compost to the soil. Specifically to: (1) determine toxic or beneficial effects of large amounts of compost on soil; (2) evaluate compost as: (a) a nutrient, (b) a soil amendment, (c) source of pollutants in ground water; and (3) the long-term effects of large amounts of compost on soil.

Significant Results: Greenhouse tests show that the N contained in compost is not available initially to higher plants, as microbes evidently divert most of the N to their own use. After 3 or 4 months in the soil, N is released from compost for higher plants. There is also evidence that high rates (60-100 tons/acre) of compost in the soil have an adverse effect on germination and produce phytotoxic effects in plants.

Compost applied to the soil in amounts above 100 tons/acre tends to increase significantly the cation exchange capacity and water holding capacity. Also, the soil appears to be aerated better after large amounts of compost are applied.

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In laboratory incubation studies small amounts of garbage compost added to soil increased fungal and bacterial populations tremendously in a short period of time. Carbon dioxide evolution was increased progressively by increased increments of compost; however, NO_3 production was curtailed initially, almost zero, where 6 to 10 g compost were added to 100 g soil.

Publications: Hortenstine, Charles C. and Rothwell, D. F. "Garbage Compost as a Source of Plant Nutrients for Oats and Radishes." Compost Science. Florida Agricultural Exp. Stations Journal Series Paper No. 2964. 3 pages.

EC-00251-04
(UI-00523-04)

CONTINUOUS INCINERATION OF MUNICIPAL REFUSE

ELMER R. KAISER
NEW YORK UNIVERSITY
BRONX, NEW YORK

Objectives: Besides developing and reporting test methods to be used in the study, the specific aims of the project are to: (1) Determine composition of refuse, grate residue, slag, fly ash, and wastewater. (2) Determine amount of grate residue, fly ash, refractory slag deposits, wastewater pollutants, and air pollutant emissions necessary for a material balance. (3) Determine values of heat release, heat transfer, and refractory furnace temperatures necessary for a heat balance. (4) Study combustion process factors and finally, determine control equipment efficiencies.

Significant Results: Design data on overfire air jets were developed and presented which will promote more complete combustion, and hence less smoke and unburned products in the stack gases. By sampling and analysis of the flames above the incinerator fuel bed it was shown that the flames are starved for combustion air. Properly designed and positioned air nozzles can provide the right amounts of air into the flames, with turbulence, for burning the gases, hydrocarbons and soot. Such jets are vital to the prevention of air pollution.

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EC-00251-04 (Continued)

Publications: Kaiser, E. R. and Trautwein, W. B. "Prevention of Fused Deposits on Incinerator Lower Side Walls." Abstract. Proceedings of 1968 National Incinerator Conference. Published by the American Society of Mechanical Engineers. pp 136-141. New York University.

Kaiser, E. R., Zeit, C. D., and McCaffery, J. B. "Municipal Incinerator Refuse and Residue." Abstract. pp 142-152. Proceedings of 1968 National Incinerator Conference. 1968.

Kaiser, Elmer R. "Thermal Processes for Refuse Reduction." Abstract, Presented at American Public Works Association. Institute for Solid Wastes. Annual Meeting held in Boston, Mass. Oct 1-5, 1967. 11 pages. New York University.

Kaiser, Elmer R. "The Sulfur Balance of Incinerators." APCA Journal. Vol. 18, No. 3. pp 171-174. March 1968. New York University.

EC-00252-05 (UI-00525-05)

SUCCESSION AND ECOLOGY OF DIPTERA IN CATTLE DROPPINGS

JOHN R. ANDERSON
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

Objectives: The basic research aim is to ascertain the factors which determine the chronological appearance of different fly species on and in cattle droppings of various ages. To determine the effects of this succession of species on the population dynamics of the various species comprising the cattle dropping community, studies will be conducted under both undisturbed pasture and experimental conditions. The effects of either or both intra- and inter-specific competition will be investigated by experimentally manipulating the habitat to either eliminate or increase the numbers of those species attracted only to droppings of certain ages.

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As the face fly, M. autumnalis, is not yet present in California, another aim is to be in a position to observe and study the impact of an exotic species on the native fauna (or vice versa).

Significant Results: No significant grant results.

Publications: Anderson, J. R.; Burger, J. F. and Poorbaugh, J. H. "The Insect Inhabitants of Undisturbed Cattle Droppings in Northern California." California Vector Views. Vol. 15, No. 3. March 1968. 35 pages. University of California, Berkeley.

Foster, Woodbridge A. "Co-operation by Male Protection of Ovipositing Female in the Diptera." Nature, Vol. 214. No. 5092, pp 1035-1036. June 3, 1967. University of California, Berkeley.

Poorbaugh, J. H. and Anderson, John R. "New Livestock Fly Moves Toward State." California Agriculture. Vol. 22. No. 3. pp 4-6. University of California, Berkeley.

EC-00253-06 (UI-00526-06)

PYROLYSIS OF MUNICIPAL REFUSE

ELMER R. KAISER
NEW YORK UNIVERSITY
NEW YORK, NEW YORK

Objectives: The main objectives of the project are to: (1) determine and assess the gasification potential of refuse. (2) demonstrate such gasification, and (3) determine the energy necessary to dry, heat and ignite the refuse.

Significant Results: It was determined that the maximum yield of organic liquids occurs when the organic matter is raised in temperature about 50°F per minute

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at atmospheric or lower pressure.

About 85 percent of the organic liquids were water insoluble and could probably be used as a low-sulphur fuel oil or feed stock for refining.

The yield of char is maximum at low rates of heating, while rapid heating increases the yield of gas. The gas is a mixture of carbon dioxide, carbon monoxide, hydrogen, methane, ethane, ethylene and higher hydrocarbons with a calorific value of 500 British thermal units per standard cubic foot. By removal of the CO_2 the calorific value could be increased to 730 BTU per cubic foot.

The char has a calorific value of over 10,200 BTU per pound. It has adsorptive powers of activated carbon which could undoubtedly be enhanced by treatment with hot steam, CO_2 or air.

Similar tests with dried sewage sludge and composted refuse indicate similar conversion potentials. Sewage sludge yielded more organic liquids than did municipal refuse.

To develop the commercial potential of refuse pyrolysis it would be advisable to undertake pilot-scale tests, from which sufficient quantities of char and liquids could be obtained for study. By upgrading the char through activation and upgrading the liquids by fractionation, hydrogenation and other treatment, they could both have a better economic return than as mere fuels.

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Friedman, S. B. and Kaiser, E. R. "The Pyrolysis of Refuse Components." Combustion. May 1968. 6 pages. New York University, Bronx, New York.

Kaiser, E. R. "Progress Report on Pyrolysis of Municipal Refuse." Progress Report dtd March 6, 1969. 5 pages.

EC-00254-03 (UI-00528-03)

POULTRY MANURE DISPOSAL BY PLOW FURROW COVER

HARRY E. BESLEY
RUTGERS, THE STATE UNIVERSITY
NEW BRUNSWICK, NEW JERSEY

Objectives: To determine the total amounts of poultry manure that can be applied and plowed under in an agricultural field and to evaluate this method as a possible solution to the problems of the poultry producers in the heavily populated Eastern Seaboard. To design equipment and methods to plow furrow and cover the poultry wastes into the soil.

Significant Results: Poultry manure was PFC applied into test plots of Freehold loamy sand (B horizon of 20% clay) in amounts equivalent to 0, 15, 30 and 45 tons of dry solids per acre. The soil was not cropped. Soil-water was sampled with suction lysimeters and soil samples were collected. Samples collected 131 days and 17 inches of rainfall after the PFC application show a downward movement of Ca, Cl, K, Mg, Na, NO_3+NO_2-N, and SO_4 to a depth of 36 inches. Samples collected 391 days and 50 inches of rainfall after the PFC application show considerable increase in element concentration at the 36 and 48-inch depths. The dissolved nitrogen (N) in

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the soil water, totaled for the soil depth from 9 to 48 inches, was 20, 186, 526, and 1026 pounds per acre for the four application rates of 0, 15, 30 and 45 tons of dry solids per acre. The maximum concentration was 700 ppm of nitrogen (N). Disposal of these large amounts of poultry manure in soil has caused large increases in the concentrations of elements in the soil water down to a depth of 48 inches.

The pollution potential to ground water was also investigated. Percolation water was collected 48 inches below ground surface by means of zero-tension lysimeters. Data for fecal coliform and total organic carbon (TOC) were obtained in addition to the elements listed above. After 7 months there was no significant difference in the TOC concentrations for the several application rates (loadings). The lack of positive fecal coliform tests with the relatively low nitrate and sulfate concentrations tend to indicate no detrimental effects to the ground water 7 months after the PFC application. However, 12 to 15 months after the application some very high nitrate, sulfate and TOC concentrations were measured in the ground water. This corresponds to the large increase in the concentration of elements noted in the soil water to a depth of 48 inches.

Laboratory experiments were conducted to evaluate the effect of variables on the rate of decomposition (as measured by CO_2 evaluation) of excreta mixed with soil. The absolute amount of CO_2 evolved was greatest at the higher loadings (up to soil: excreta = 1:1), but the percent decomposition of added excreta was greatest at the lower loadings (down to 10:1). Temperature (4, 12 and 20C) had little effect on the rates of CO_2 evaluation at the lower loading regimens. Successive increments of excreta decomposed about as rapidly as the original addition. At low loadings, soil texture had little effect, but at higher loadings decomposition was fastest in the lighter soils tested. A salt concentration equivalent to about 8 excreta applications at the low rate inhibited decomposition only slightly.

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Any method of disposing of chicken excreta should take into account the possible presence of substantial numbers of Salmonellae which are human pathogens. Approximately 30 percent of the excreta samples obtained from commercial farms contained Salmonella.

Publications: No additional publications.

EC-00255-03 (UI-00535-03)

NONCOMBUSTIVE DISPOSAL OF SOLID AGRICULTURAL WASTES

ELLIS F. DARLEY
UNIVERSITY OF CALIFORNIA
RIVERSIDE, CALIFORNIA

Objectives: General: To determine (1) The feasibility of shredding woody wastes and incorporating them into the soil. (2) The effect of this incorporation on crops.

Specific: To determine (1) Shredding capabilities and costs. (2) Whether or not the shredded material can serve as a focal point for the development and spread of the root rot Armillaria mellea, and of the pathogens Phytophthora and Verticillium; and if so, how to discourage its spread chemically, and yet not inhibit development of beneficial soil saprophytes. (3) The possibility of controlling Scolytus regulosus (shothole borer) by shredding and discing, cultural practices, and biological and chemical control.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

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EC-00256-03 (UI-00536-03)	USING WASTES FORMED IN VEGETABLE AND CHEESE PRODUCTION	AMIHUD KRAMER UNIVERSITY OF MARYLAND COLLEGE PARK, MARYLAND

Objectives: To determine if a substantial portion of the waste by tomato canneries and dairy plants manufacturing cheese could be converted into useful nutritional food, and at the same time eliminating the waste disposal problem.

Significant Results: A procedure was developed by which the tomato cannery waste could be utilized in part as cattle feed having a nutritional value intermediate between corn and alfalfa. At the same time most of the tomato proteins were isolated, and could be used as a protein supplement in protein deficient diets. Any waste remaining after the production of animal feed and the protein concentrate may be used as a soil nutrient and conditioner, provided this residue consists largely of other than fully ripe tomato materials which contain phototoxic properties.

The cheese wastes, which consist mostly of whey, could not be used for production of many food products previously because of protein instability which was solved under this project previously. During FY 1969, therefore, acid and sweet whey were anaerobically and aerobically fermented with and without the additon of fermentable sugars and the appropriate microorganisms. Whey wine with alcohol levels ranging from 5-10 percent and whey vinegar with an acetic acid level of 4 percent were prepared. Ice cream, sherberts, cultured whey, and citrus fruit drinks were also prepared using, whey solids as replacement and/or supplemental components. All of the above products have been taste-tested for acceptability, providing a good indication that the massive quantities of available whey solids presently classed as waste products can be utilized effectively in the development of new and supplementation of existing foods.

Publications: No additional publications.

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EC-00257-02 (UI 00537-02)	STUDIES ON MODIFICATIONS OF SOLID INDUSTRIAL WASTES	CORNELIUS S. GROVE, JR. SYRACUSE UNIVERSITY SYRACUSE, NEW YORK

Objectives: Solid industrial wastes arise from many differing sources in chemical process industries. As such they vary in many physical and chemical properties. Some are acid or alkaline; others are saline; others are inert; others may be toxic. Characteristically, few solid industrial wastes can support useful vegetation until many years have passed after their initial deposition. The major objective of this proposed research is to determine the physical and chemical properties of major solid industrial wastes and to study modifications of these properties that will permit rehabilitation and beautification of the presently barren land areas covered by deposition of these wastes.

Significant Results: In collecting data and information for evaluation it was found that personal correspondence and direct contact interviews were very valuable to obtain primary data and to confirm published data. Summarization of significant data reinforce conclusions that the scope of the total solid industrial waste problem in quantity is seven to ten times the amount of municipal solid wastes (frequently quoted as two to one). The widely varying quality or composition of these solid industrial wastes necessitates a multifold approach to handling and disposal methods.

One particular type of solid industrial wastes is the waste material generated by the Solvay Process for the manufacture of soda ash. This solid material is composed of a high percentage (about 35 percent) of soluble salts dispersed in a matrix of finely divided insoluble particulates. In various localities, large areas of land have been used for deposition of the solid wastes from this chemical process. Removal of soluble salts by natural water infiltration and leaching is very slow; waste beds from 50 to 100 years of age are still leaching. Rehabilitation of these waste disposal areas is inhibited by the salt content preventing growth of suitable cover vegetation

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and by the lack of suitable load-bearing characteristics causing settling of structures and even of reinforced concrete highways. The major conclusions based on current experimental studies are: (1) Leaching of the soluble salts can be increased in rate provided that a suitable sub-surface drainage system is installed; (2) vegetation will develop in top-soil placed over the solid waste material if proper drainage is maintained so that leaching overcomes capillarity; and, (3) load bearing can be improved if more rapid leaching and removal of soluble salts are carried out.

Publications: Grove, C. S., Jr., Kestner, Mark L. and Nemerow, N. L. "Rehabilitation of Solid Industrial Wastes Disposal Sites". Manuscript 28 p. For presentation at 24th Purdue Industrial Waste Conference. May 8, 1969.

EC-00258-03
(UI-00540-03)

CITRIC ACID FROM CITRIC WASTES BY FERMENTATION

STERLING K. LONG
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

Objectives: To develop a method for disposal of citrus processing plant wastes through fermentation.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

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EC-00259-03 (UI-00541-03)	PIPE TRANSPORT OF DOMESTIC SOLID WASTE	IRAJ ZANDI UNIVERSITY OF PENNSYLVANIA PHILADELPHIA, PENNSYLVANIA

Objectives: To examine the applicability of the technology of bulk solid transport in pipelines to the collection and removal of solid waste. Whether the pipeline transport of solid waste may be considered as a serious alternative to the truck collection depends upon the answers to two questions: (1) Is pipeline transport of solid waste technologically feasible? And (2) How does solid waste pipeline compare economically with the present truck collection?

Significant Results: Established that the fully automatic collection and removal of domestic solid waste in pressured pipes is technologically feasible and under conditions prevailing in the core of a metropolitan area (such as center city of Philadelphia) is also economically attractive (if the disposal point is 50 miles away, it is less expensive than truck collection). It was also found that the cost of collection and removal from each premise in a residential community (such as Radnor, Pennsylvania, pop. 30,020) for pipeline is slightly more than double the present truck collection. The system becomes economically attractive if each three or four houses is served by one access to the pipeline. In addition, a prediction equation has been developed which enables one to design solid waste slurry pipelines.

Publications: Yen, Jing. G. and Zandi, I. "Transport of Slurries in Heterogeneous Regime." Soc. of Mining Eng. of AIME: #69-B-70. 28 pp. University of Pennsylvania.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00260-04 (UI-00547-04)	COMPREHENSIVE STUDIES OF SOLID WASTES MANAGEMENT	PERCY H. McGAUGHEY UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

Objectives: To develop solutions to the problem of solid wastes management through a program of research which brings the competence of specialists in the wide variety of disciplines involved in planning, financing, and administering a community into effective combination with that of engineers and environmental health specialists.

Significant Results: Studies are being made which involve the coordinated activities of specialists in planning, operations research, economics, three fields in engineering, biology, and ecology---all working towards the development of an overall wastes generation and management model of general applicability.

Inputs to the model completed thus far include the development of a relationship between the quantity of waste generated and the population and types of activity within a selected nine-county study region. Models have been developed relating to optimal location of treatment plants and disposal sites. Least-cost flow patterns of wastes from origin to disposal sites have been determined; as have been optimum operating policies for treatment plants with random varying wastes loads.

Studies concerned with technology were centered on the adaptation of five "non-conventional" technologies to the treatment and reclamation of wastes. Thus the following small scale pilot plants were built: rough composting, anaerobic digestion, wet oxidation, pyrolysis, and biological fractionation. Anaerobic digestion, wet oxidation, and biological fractionation are of special interest since they are suited to the treatment of wastes transported by present-day conventional methods, or by pipe transport should that method prove feasible in the future. Use of the land as a receptor for roughly composted refuse was successfully demonstrated by pilot plots, but revealed weather difficulties which limit feasibility of the process. The digestion

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studies showed that the various constituents of refuse, individually and collectively, either digest readily, or pass through the digester without affecting the efficiency. Wet oxidation of the wood fraction of refuse produced several useful chemicals, of which acetic acid was the most abundant. At present, paper and municipal refuse are being processed. The data had not been analyzed at the time of this writing.

A 200 lb/hour pyrolysis-combustion plant has been constructed and now is being readied for experimental runs involving the use of refuse. The plant will be able to process refuse so that, if desired, useful intermediate products can be produced; or, if no market exists for the products, the destruction process can be carried on to completion, i.e. to CO_2, H_2O, and mineral ash. It differs from conventional pyrolysis processes in that charcoal need not be produced. The work in biofractionation led to the selection of Trichoderma viride as the organism best suited to the hydrolysis of the cellulose in refuse to glucose. The conditions under which hydrolysis proceeds most efficiently have been determined. Work now is in progress on developing suitable processes for converting the glucose product into useful protein, and into substrates for fermentation processes.

Studies on the economies of scale in incineration, landfill, and transfer stations are about completed. The break-point for landfill operations apparently is about 200 tons/day. Preliminary economic analysis to evaluate the practical feasibility of the five technologies showed that of the five, biofractionation showed the least promise.

A significant by-product of the project is its educational impact on the participants in it. During the course of its conduct, professionals in six disciplines have become oriented in their thinking towards the solid wastes management problem, and thus will be in a position to apply their particular specialties to arriving at solutions to the problem.

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EC-00260-04 (Continued)

Publications: Nigram, Avadhesh K. and Anderson, Loren E. "Comprehensive Studies of Solid Wastes Management. A Mathematical Model for the Optimization of a Waste Management System." SERL Report No. 68-1, 63 pp. February 1968. University of California, Berkeley.

EC-00261-04 (UI-00549-04)

HOSPITAL SOLID WASTE DISPOSAL IN COMMUNITY FACILITIES

RICHARD G. BOND
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA

Objectives: To describe and evaluate the disposal of hospital solid wastes in the community. Items which are being considered include quantities and types of waste released into the community, the ability of the community to accept and dispose of these solid wastes, and the consequences of such disposal. Possible public health implications are being studied. It is expected that data will provide for the design of new hospitals, the rehabilitation of existing hospitals, and the improvement of operation.

Significant Results: Completion of the previously initiated field operations phase of the research, with the last of a total of 112 hospitals being visited. The hospitals were all nongovernmental, nonprofit general hospitals and ranged from approximately 50 to 1,100 in-bed capacity. Studies at these hospitals yielded a total of some 25,000 items of data, plus narrative. In addition, preliminary calculations, again previously initiated, were completed for data from all surveys, involving a total of some 20,000 individual calculations.

Other progress included considerable editing of data, transfer of much of the data to punch cards for electronic data analysis, development and adaptation of several computer programs for use in the research, and updating of the literature review.

Publications: No additional publications.

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EC-00262-02 (UI-00551-02)	BIOLOGICAL CONVERSION OF ANIMAL WASTES TO NUTRIENTS	BYRON F. MILLER COLORADO STATE UNIVERSITY FT. COLLINS, COLORADO

Objectives: This research will investigate the conversion of poultry wastes into animal and vegetable proteins and foodstuffs. This work will involve a three-phase approach to the problem utilizing a combination of biological systems in the degradation of poultry manure, simultaneously producing animal and plant products. It will involve the effectiveness of the decomposition of the manure efficiency of changing manure energy and nitrogen (protein and non-protein) into useful items.

Phase I. Biological degradation of manure by feeding to selected animal species.

Phase II. The culture of useful plants under greenhouse conditions employing the effluent waters produced during the biological treatment investigated in Phase I.

Phase III. The combination of plant and animal systems in one ecological unit to investigate the balance of gaseous and solid wastes needed for the system.

Significant Results: Five species of diptera (flies) were screened as potential means of converting poultry manure to high quality protein for animal feed. Musca domestica (housefly) was selected because it reproduced in large numbers and required a minimum of time (5 to 10 days) to reach pupal stage. It was found that 3 grams (about 60,000) of fly eggs to 4 kilograms of manure gave optimum yield of pupae. The fly larvae effectively reduced the problem of manure disposal by eliminating 60 percent of the moisture and 80 percent of the organic matter during the digestion period. In addition, the wet, pasty, odoriferous manure was converted to a granular, stabilized, inoffensive product that was easily dried.

About two percent of fresh manure weight was havested as dried fly pupae. These pupae contained 60 percent protein, comparable to fish meal as a protein supplement

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for starting chickens. The pupae are a good source of minerals as well as some vitamins.

The housefly will feed on a wide variety of waste materials so it may prove quite useful in solving other waste disposal problems. Through the controlled production of fly pupae, the number of wild flies would be reduced because their breeding sites were eliminated. While helping to solve a very difficult waste problem the housefly can be utilized as a protein supplement and aid in the control of wild, disease carrying flies. Most of the fertilizer value is retained in the manure residue.

A poultry operation of 400,000 laying hens would produce 1600 pounds of dried fly pupae daily. At a price of 10 cents per pound, this would amount to $160 per day. In addition, the manure residue could be used as fertilizer.

Publications: None

EC-00263-04
(UI-00552-04)

PARTIAL OXIDATION OF SOLID ORGANIC WASTES

WILLIAM W. SHUSTER
RENSSELAER POLYTECHNIC INSTITUTE
TROY, NEW YORK

Objectives: To investigate the possibilities of reacting certain organic components of solid wastes with limited quantities of oxygen. The purpose of this treatment is to reform the organic components of the waste into simpler organic compounds of economic interest. Thus, municipal waste will be regarded as a possible source of useful products.

It is planned to extend present work being done with paper as a raw material, to include lawn trimmings, leaves and other major components of municipal refuse. The effects of air-solid ratios, temperature and moisture content on the product composition will be studied.

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EC-00263-04 (Continued)

Significant Results: A fluidized bed reactor has been built for the process to be employed and has obtained some preliminary results.

Publications: Shuster, William W. "Partial Combustion of Solid Organic Wastes." Engineering Foundation Research Conference. Exhibit A. Rensselaer Polytechnic Intitute. Troy, N. Y.

EC-00264-03 (UI-00553-03)

FATE OF INSECTICIDES IN COMPOSTED AGRICULTURAL WASTE

WALTER W. ROSE
NATIONAL CANNERS ASSOCIATION
WASHINGTON, D. C.

Objectives: To determine the fate of pesticides which might be included in the solid waste output produced by canneries. To isolate the microorganisms found in the composting operation, which would apparently decompose insecticides and study pure and mixed cultures as to their ability to break down insecticides and the effect of various operating parameters of composting on the degradation of the pesticides. To study the pathway for the formation of degradation products of insecticides by microorganisms.

Significant Results: Experiments were carried out to complete the effect of the compost process on the fate of six selected insecticides. Two carbamate type insecticides were studied and enumeration of the microflora into numbers of bacteria, actinomycetes and fungi was also performed.

Results for the microflora were similar to those obtained from the earlier work. Bacteria predominated throughout the experiments in both the conventional batch type and the continuous thermophilic compost processes. The actinomycetes were next largest in numbers followed by the fungi.

Under certain conditions it was found that zineb and carbaryl residues did not

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persist for long periods of time. The disappearance of these compounds from the compost was found to be highly dependent on the pH of the compost mixture. A high pH, above 7.0, accelerated the loss of the two insecticides, whereas a low pH slowed down the rate of loss.

Laboratory studies with buffered insecticide solutions confirmed the effect of pH on the loss of carbaryl. Studies were conducted at pH 4.0, 7.0, 8.0, and 9.0. At a pH of 8.0 or 9.0 the initial concentration of approximatly 60 ppm carbaryl was reduced to a non-detectable level within 22 days. At pH 7.0 about 80 percent was lost within 50 days of incubation. At pH 4.0 very little change in the insecticide concentration occurred within the 50 days of incubation.

Although pH was mainly responsible for changes in the insecticide concentration, there was evidence to indicate that the microflora played two important roles in causing the insecticides to degrade.

Under natural conditions, the microflora raised the pH of the compost material to a level which resulted in the loss of the insecticide. At pH 8.0 and 9.0 buffered inoculated samples showed a faster removal rate than the buffered non-inoculated samples. This suggests that the microflora may share in the degradation of the insecticide with the pH.

Publications: Rose, Walter W. and Mercer, Walter A. "Fate of Insecticides in Composted Agricultural Wastes." Progress Report - Part I, July 1968. 27 pp. Prepared by Western Research Lab. National Canners Association, Berkeley, Calif.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00265-02 (UI-00554-02)	A STUDY OF INSTITUTIONAL SOLID WASTES	JERRY C. BURCHINAL WEST VIRGINIA UNIVERSITY MORGANTOWN, WEST VIRGINIA

Objectives: To study the production of solid wastes from an institution, in this case a university teaching hospital and basic science complex, in order to establish unit production figures. The study encompasses quantity of waste produced per bed, per department etc., its physical, chemical, bacteriological and virological composition, establishment of design quantities for engineers and architects, and a statistical analysis to ascertain the reliability of the data collected.

Significant Results: Four areas of this research project were emphasized during Fiscal 1969. These were: (1) determining the physical and chemical characteristics of wastes from one medical school and referral complex, (2) determining whether bacteria and viruses were present to any significant degree, (3) providing a classification basis and obtaining quantity values for the wastes from significant areas of the medical school and hospital, and (4) developing a method of reporting wastes on a unit basis of some type.

In the study of physical and chemical characteristics, methods were developed for samplying the wastes from the medical school and hospital. Gross waste production was obtained by weighing all wastes produced at the institution. Representative samples of the gross weight production were collected and the physical characteristics of these representative samples were compared with those of the gross samples to verify approximate like percentages. Chemical analysis was performed on the representative sample.

Virological studies consisted of first attempting to recover known inoculations of viruses in waste materials. After it had been verified that these viruses could be recovered, wastes were studied with known inoculants to determine the longevity

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of the viruses. It was verified that viruses could exist in solid waste materials for periods of 3 to 5 days. Air sampling equipment was used in the vicinity of the waste collection points and at the incinerator to determine the presence of airborne bacteria.

Sampling procedures were developed in such a manner that it is now possible to say what type of waste and how much per patient may be expected from various significant areas in the hospital such as the surgical ward, the obstetrics ward and others. Unit waste production per patient, per total hospital population is being developed.

Although not part of the original specific aims of this research project a cost analysis of the collection and disposal of solid wastes was made. The analysis showed this figure to be approximately $80 per ton.

Publications: None

EC-00266-04
(UI-00555-04)

PYROLYSIS OF SOLID MUNICIPAL WASTES

DONALD A. HOFFMAN
CITY OF SAN DIEGO
SAN DIEGO, CALIFORNIA

Objectives: (a) To determine the optimum temperature, initial moisture content, and period of exposure for pyrolysis of various types and mixtures of refuse.

(b) To analyze by means of gas chromatography, infra-red spectroscopy, and other techniques, the hot volatile products of pyrolytic decomposition, i.e. to determine the gaseous products that can be used to provide heat for the system and the composition of liquid tar-like substances from which by-products can be recovered.

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(c) To investigate the properties of the solid residue in order to determine if it should be discarded as fill material or utilized as a fuel.

(d) To estimate the economic parameters associated with this system in order to ascertain its feasibility vis-a-vis other methods for handling municipal refuse.

Significant Results: The products of pyrolysis (destructive distillation) of solid municipal wastes are char, gases and volatile liquids. The relative amounts of gases, liquid organics and tars produced are significantly affected by the temperature at which pyrolysis occurs and the bulk density of the sample pyrolyzed. The relative amounts of char and its calorific value are not significantly changed by varying temperature and compaction.

The energy produced by the incineration of the products of pyrolysis of solid municipal wastes generally received at San Diego's fill sites would be more than sufficient to sustain the process,and the resulting residue would be more satisfactory fill material than the wastes as received.

Integrating the pyrolysis process into San Diego's solid wastes disposal program would result in a reduction of volume of wastes requiring disposal such that the life of San Diego's sanitary fill sites would be tripled.

Sulfur determinations run on the pyrolysis products indicate that incineration of these products to sustain the process would not result in air pollution as defined by Rule 53(a) of the San Diego County Air Pollution Control District.

Relatively large amounts of plastics, glass and metals have been included in pyrolyzing charges. Plastics depolymerize readily and although glass and metals soften somewhat at the temperatures studied (1200° & 1500°F) such softening would not

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apparently cause significant problems in the operation of a large plant.

Disposal of grits from the sewage treatment plant, manures and garbage were investigated. Pyrolysis would be an effective means of disposal but would require fuel in addition to the incineration of products to sustain the pyrolysis of these wastes.

Publications: No additional publications.

EC-00267-06 (UI-00558-06)

BIOLOGICAL CONSEQUENCES OF PLANT RESIDUE DECOMPOSITION IN SOIL

WILLIAM C. SNYDER
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

Objectives: To investigate the phytotoxins. To separate and characterize some of the major active components generated during plant residue decomposition. To determine whether such compounds can break down the resistance of resistant host varieties. Explore the biological activities of the compounds using other host-pathogen combinations.

Significant Results: The emphasis of research (on the role of crop residues in the biology of root diseases) changed from a study of residue decomposition products in the soil and their effects on host and parasite to a study of the plant pathogens utilizing crop residues as substrages. It was found that Pythium, and in particular Pythium ultimum, a ubiquitous soil fungus capable of attacking young root tissue of most plant species, was able to utilize all green crop residues tested, as a substrate for increasing its soil population. In the first few weeks following green crop incorporation into the field the population of P. ultimum was markedly increased, as was its inoculum potential measured by damage to lettuce seedlings. In succeeding weeks, however, though P. ultimum populations remained higher than

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in soil where green crops were not incorporated, the inoculum potential was lower than in control soil. This apparent "biological contest" of a high P. ultimum population by the later stages of crop residue biodegradation was further demonstrated in greenhouse experiments. Here P. ultimum damage was virtually eliminated in plantings made two weeks after green crop incorporation into field soils at rates equal to those expected in the field. Further work is being directed at (1) the mechanisms involved in the negation of the normal effect of the Pythium population by decomposing crop residue and its microflora and (2) the soil physical conditions which most rapidly allow the crop residue to produce a high level of biological control of P. ultimum.

It was found that P. ultimum population increases up to 4 x in soil adjacent to green rye leaves less than 48 hours after the rye is placed in soil. In 120 hours the increase can be 10 x.

Publications: No additional publications.

EC-00268-02 (UI-00559-02)

THERMOPHILIC AEROBIC PROCESS FOR WASTE TREATMENT

JOHN F. ANDREWS
CLEMSON UNIVERSITY
CLEMSON, SOUTH CAROLINA

Objectives: To study the application of a thermophilic aerobic digestion process to the treatment of organic waste, particularly to wastes containing three to five percent solids. To develop a theoretical mathematical model for the process which will express effluent substrate concentration, effluent organism concentration, and heat production as functions of input substrate concentration, detention time, and oxygen supply rate.

Significant Results: Thermophilic aerobic digestion, the subject of this research, is a process which appears to have great potential for treatment of these organic solids.

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Both dynamic and steady-state mathematical models have been developed for the process. The steady-state model has been experimentally verified for a simple substrate using continuous-flow, complete-mixing reactors. Experimental studies to verify the dynamic model are now in progress. Simulation studies using the steady-state model show that the process would represent an improvement over conventional aerobic digestion and would be self-sustaining with respect to temperature for the treatment of waste-water sludge either alone or mixed with garbage. Simulation studies using the dynamic model indicate that the process is stable and qualitatively define the proper operating conditions for the process.

Publications: Kambhu, Kawi and Andrews, John F. "An Aerobic Thermophilic Process for the Biological Treatment of Wastes." Simulation Studies. A Publication of the Environmental Systems Eng. Dept. Clemson Univ. South Carolina. The 41st Annual Water Pollution Control Fed. Conf. Chicago, Ill. Sept. 23, 1968.

EC-00269-02
(UI-00560-02)

POULTRY OFFAL SILAGE AS A FEED INGREDIENT

CHARLES H. HILL
NORTH CAROLINA STATE UNIV.
RALEIGH, NORTH CAROLINA

Objectives: The broad research objective of this project is to make economical use of material that is now a waste product. As a waste product, poultry offal presents a pollution problem. However, poultry offal contains nutrient elements which have been assimilated into the bodies of chickens and it is the purpose of this project to make effective use of these nutrients for feeding livestock, particularly poultry and swine.

A subsidiary objective of the project will be the identification of the component in poultry offal silage responsible for the increased growth.

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Significant Results: The studies conducted are continuation of the effort to determine the usefulness of a waste product, poultry offal, as a feed ingredient. In numerous studies both in the laboratory and under field conditions poultry offal, if it is made into silage, increases the growth of chickens. The silage made from offal is a more consistent growth promoter than some of the common antibiotics. In most cases it is as good as fish meal which is a much more expensive product.

Further experiments have shown that poultry offal which has not been ensiled does not increase the growth of chicks. The factor responsible for the growth promoting effect is stable to autoclaving, and it is not extracted by ether, acetone, ethyl acetate or ethanol. Studies are continuing in an effort to determine the nature of the growth stimulant.

One of the goals of this project was to show that a waste product and a potential pollutant could, in fact, be put to good economic use. This goal has essentially been reached.

Publications: None

EC-00270-02
(UI-00561-02)

ANIMAL WASTE COMPOSTING WITH CARBONACEOUS MATERIAL

CHARLES B. DAVEY
NORTH CAROLINA STATE UNIV.
RALEIGH, NORTH CAROLINA

Objectives: This proposal covers the combining of two solid waste products, which may exist in large quantities in proximity to each other in many areas, and composting them by means of an aerobic thermophilic process to produce a valuable soil amendment. The materials to be considered cannot be composted satisfactorily due to an improper carbon-nitrogen balance. Examples of such materials might be poultry manure which has a very low carbon to nitrogen ratio and sawdust which has a very high carbon to nitrogen ratio.

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Significant Results: The initial studies investigated the high rate, thermophilic composting of poultry manure and sawdust mixtures.

The mixtures are composted in an aerated rotating drum having a capacity of 45 cubic feet. Carbon to nitrogen to phosphorous ratios (C:N:P) ranged from 21:1.0:0.19 to 43:1.0:0.15.

Aerobic, thermophilic composting was found to be an effective method of stabilizing the sawdust manure waste mixture. The manure fraction contains a high percentage of available carbon which is quickly utilized by the microorganisms. The sawdust is more resistant to decomposition; however, it is an effective filler material which helps reduce the moisture level of the mixture. If the moisture level exceeded 65 percent, mud balls form.

Seven cubic feet of air per pound of volatile solids per day were required in order to maintain a residual of 5 percent oxygen in the exhaust gas stream. The maximum oxygen uptake rate was 4.16 milligrams of oxygen per hour per gram of volatile solids. This rate was achieved during runs having continuous mixing.

The nitrogen loss from the compost averaged 3.29 percent for well aerated continuously mixed process, while it averaged 6.37 percent for intermittently mixed compost. This can be related to the greater biological activity found in the continuously mixed process (related to the greater oxygen uptake rate).

The length of time required for batch composting varied from 7 to 10 days for intermittently mixed batches to 5 to 6 days for continuously mixed batches. Batches were considered completed after the temperature of the batch dropped below the thermophilic level. On removal from the composter, the compost was coal black in color and had a slight ammonia odor.

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Both the physical and chemical characteristics changed markedly during a period of 6 to 8 weeks in storage following composting. The color changed to a whitish-black while the odor became similar to a fresh soil. The holocellulose content decreased to a fairly stable level and the cation exchange capacity increased to a level characteristic of desirable soil conditioners.

Publications: None

EC-00271-02
(UI-00565-02)

DEGRADATION OF WASTE PAPER TO PROTEIN

JOHN B. DOUROS
UNIVERSITY OF DENVER
DENVER, COLORADO

Objectives: This research will evaluate a fermentation method of converting or partially converting waste paper to a protein supplement for livestock feed. The first phase would include isolation and screening of microbes to find suitable strains for rapid digestion of cellulose in a water medium enriched with various stimulants. Shake flask studies for preliminary determination of fermentation rates would be included. The second phase will involve studies of continuous fermentation in stir jars to obtain necessary (a) data for preliminary economic analysis (b) data for design of a pilot plant, and (c) protein for preliminary animal testing. Depending upon success of the first two phases the third phase of the program will involve design, construction, and operation of a 200-400 lb/day pilot plant to obtain performance data necessary for economic evaluation and product for the fourth phase of the study; namely, nutritional studies on livestock to evaluate digestibility, palatability, etc.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

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EC-00271-02 (Continued)

Publications: Douros, J. D. and Updegraf , David M. "Degradation of Waste Paper to Protein." Progress Report. Period c vered 6-1-67 to 2-28-69. 25 page report (combined reports of April 1968 and December 30, 1968). University of Denver.

EC-00272-03 (UI-00566-03)

PHOTOSYNTHETIC RECLAMATION OF AGRICULTURAL SOLID AND LIQUID WASTES

WILLIAM J. OSWALD
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

Objectives: To convert a large fraction of agricultural wastes now causing severe environmental problems such as odor, unsightliness, and fly breeding to a usable material. The project includes a detailed study of the basic characteristics of an integrated anaerobic fermentation and algae growth system for agricultural solid and liquid wastes on a small pilot plant scale. To study the reaction kinetics and overall performance of an anaerobic reactor or pond followed by an algae growth reactor or pond. Recirculation of algae-free effluents will be employed for odor control in the anaerobic pond and for nutrient transmission into the algae growth pond. Area and volume requirements per unit weight of waste and weight yields of algae per unit weight of waste will be determined.

Significant Results: A biochemical system has been developed and operated in which the solid and liquid wastes resulting from poultry and egg production are automatically flushed into an algal-bacterial system in which there is reclaimed water. When climate permits the wastes are rendered stable and odor-free and a substantial fraction of the nitrogen and phosphorous contained in the waste are fixed by protein-rich algae. After separation and drying the algal material has been used as a protein supplement in the chicken diets with no decrease in growth, egg production, or egg quality, as compared with conventional diets. Fly problems are eliminated and odor nuisance is greatly diminished by the system. The volume of solid waste requiring ultimate disposal is reduced by 75 percent. In theory, where climate permits, up to 80 percent of the nitrogen can be recycled in the

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system, thus greatly reducing feed requirements. Due primarily to poor separation equipment the best nitrogen recovery obtained thus far has been 25 percent of the theoretical possible. For this reason improved algae separation equipment has been installed and will be used in the near future. It is hoped that with new equipment nitrogen recovery may attain 80 percent of the theoretical.

Future studies will involve optimization of the regenerative process for maximum benefit cost ratios with respect to water resources, waste disposal, and nutrient recovery. Also to be studied is an extension of the process to transport, treatment, and reclamation of dairy and feed lot wastes.

Publications: Ichikawa, K., Golueke, C.G. and Oswald, W. J. "Biotreatment of Steffen House Waste." Jo. of the American Soc. of Sugar Beet Technologists. 15(2). 125-150, July 1968. University of California.

Dugan, G. L, Golueke, C. G. and Oswald, W. J. "Photosynthetic Reclamation of Agricultural Solid and Liquid Wastes." Paper presented at the Engineering Foundation Research Conference. "Solid Waste Rsch & Dvpmt, II." July 22-26, 1968. Wayland Academy, Beaver Dam, Wisc.

Dugan, Gordon L., Golueke, Clarence G. Oswald, W. J. "Hydraulic Methods of Transporting Chicken Wastes in a Semi-Enclosed Biosystem." Paper presented before the Scientific Advisory Committee of the Pacific Dairy and Poultry Assn. at the 45th Annual Meeting in Palm Springs, California. March 18, 19, 1969. 17 pp.

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EC-00273-02 (UI-00570-02)	WASTE COMPOSTS AS CHELATING AGENTS IN PLANT NUTRITION	WILLARD L. LINDSAY COLORADO STATE UNIVERSITY FT. COLLINS, COLORADO

Objectives: Chelating agents are known to increase the solubility of some of the more insoluble plant nutrients in soils. The objectives of this research are to examine critically the beneficial effects of solid waste composts in increasing plant growth on soils where specific micronutrient disorders are known to occur. Soluble extracts will be obtained from soils in which various types of organic residues are permitted to decompose. An attempt will be made to identify the active metal-complexing groups and to assess their importance in plant nutrition. Initial studies will be made on calcareous soils which have demonstrated nutrient deficiencies of iron and zinc.

Significant Results: Activated sewage sludge from Denver and garbage compost from Boulder, Colorado were tested as iron and zinc fertilizers in a greenhouse on soils deficient in these nutrients. All other nutrients were adequately supplied in these tests.

Addition of sewage sludge to a zinc-deficient soil increased the growth of corn, zinc content of the tissues, and plant-available zinc in the soil. Toxicity and reduced plant growth resulted when the sewage sludge was added at 8000 ppm. Ashing the sewage sludge reduced toxicity but also greatly reduced its effectiveness as a zinc fertilizer. Garbage compost was not toxic at the 8000 ppm level, but was less effective than sewage sludge in correcting Zn deficiency.

Activated sewage sludge slightly increased sorghum yields on an iron-deficient soil but failed to increase the iron content of the plants. This material initially contained a large amount of available iron, but its availability declined rapidly after addition to soil. Garbage compost was less effective than sewage sludge in

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correcting non-deficiency, but its effectiveness improved slightly over a 20-week period.

The results indicate that solid waste products such as garbage composts and sewage sludge have some value as micronutrient fertilizer on soils deficient in these nutrients. Work is underway to identify the chelating agents released during the decomposition of these wastes in soils. Such chelating agents have been shown to play an important role in the solubilization and movement of plant nutrients in soil.

Publications: None

EC-00274-02 (U1-00572-02)

UTILIZATION OF FIBROUS WASTES AS SOURCES OF NUTRIENTS

JAMES M. LEATHERWOOD
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

Objectives: To develop a biological technique for the conversion of natural cellulosic wastes to products that can be utilized as nutrients by animals.

Anaerobic cellulolytic bacteria and enzyme preparations from fungi will be used as hydrolytic agents to degrade cellulose in natural wastes. The products of fermentation will be fed to animals in order to determine their nutritive value. Primary emphasis will be given to the selection of microorganisms and to the determination of the optimum fermentation processes.

Significant Results: Significant information has been revealed with respect to the enzymic hydrolysis of cellulose. In studies with Ruminococcus albus, the complex formation of a complete cellulase as the result of the interaction of two different proteins has been demonstrated. This phenomenon occurs between two different colony-

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types of this obligate anaerobic bacterium when grown on cellulose-agar roll tubes. On the basis of this reaction, a new mechanism for the enzymic hydrolysis of cellulose has been postulated. These findings also have revealed information on the resistance of cellulose to hydrolysis and should lead to the development of techniques to increase the rate and extent of cellulose degradation. The formation of tube-like structures on cellulolytic bacteria by means of scanning electron microscopy have been observed. These structures do not develop when the bacterium is not grown on cellulose. Preliminary data suggest that these morphological changes are involved in excretion of the extracellular enzymes which are responsible for cellulose degradation. Recent studies on the genetic control of cellulase synthesis by these anaerobic bacteria have shown that enzyme synthesis is repressed when soluble sugars and other energy sources are available for growth. Attempts are currently being made to alter this genetic control by means of chemical mutagens in order to develop a mutant with constitutive synthesis of the cellulase.

Small fermenters with either cotton linters or newspaper pulp as substrates are inoculated with the cellulolytic bacteria and are supplied with inorganic nitrogen and buffer solutions. The bacteria degrade the cellulose to yield energy products and use the inorganic nitrogen to synthesize bacterial protein. The yield of energy and protein from these fermenters has been low, however, several techniques are being investigated to increase the yield. In addition to altering the operation procedures for the fermenters, preliminary evidence shows that inclusion of a methanogenic bacterium will stimulate the yield.

Publications: None

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EC-00275-01 (UI-00573-01)	USEFUL DISPOSAL OF AUTO BODIES AND DISCARDED TIRES	EDDIE J. WREN GULF SOUTH RESEARCH INSTITUTE BATON ROUGE, LOUISIANA

Objectives: To conduct engineering and economic studies of methods for compacting auto bodies and discarded tires into levee and foreshore protection materials.

(a) Determine physical configurations of compacted auto bodies which yield best weight and cost per square foot coverage ratios.

(b) Develop simple forming dies for the shaping and the interlocking features required for the compacted mass.

(c) Experiment to develop the effects of compacting auto tires within the auto bodies.

(d) Determine rust inhibitor requirements.

(e) Determine stream pollution potential.

(f) Study the economics of a mobile compacting facility installed on board a river barge.

(g) Study the economics of establishing concealed derelict auto collection points along the waterways. (Aid in highway beautification)

(h) Study the complete economics of the methods adopted to determine the potential commercial interest in the proposed method.

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Significant Results: The research team investigated, in particular, the feasibility of compacting these automobile hulks into a more dense form for possible use in Mississippi River levee protection. Three basic types of river protection work were studied. These were (1) construction of levee slope protection surfaces; (2) underwater shoreline stabilization; and (3) foreshore dike protection.

A substantial quantity of concrete and broken stone (riprap) is required to maintain existing protection dikes and to meet the needs for new levee protection. The U. S. Army Corps of Engineers (New Orleans District) reports that 1,762,000 tons of material will be required for planned new construction. Investigations by the project team revealed that if all of the estimated 160,000 junked automobile bodies in Louisiana were available, (each yielding approximately one ton of metal) this 160,000 tons would not be sufficient to meet half of the annual riprap tonnage required by the New Orleans District of the U. S. Corps of Engineers to maintain existing foreshore dikes. Furthermore, the density of a stripped automobile body, compacted to 50 cubic feet, is approximately 30 pounds per cubic foot, compared with 120 pounds per cubic foot for riprap. The cost of asphalt and sand mixes to protect the metal from rusting and to bring the density up to acceptable levels is too great to be competitive with present riprap cost.

It was concluded that other applications for compacted automobile hulks should be investigated on a local basis because of the following factors:

(1) the vast organization of supply points which would have to be set up along the Mississippi River to meet the demand for compacted hulks;

(2) the unfavorable economics of collecting, inventorying, and transporting huge quantities of automobile hulks;

(3) the low density of the product; and

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(4) the seasonal (river stages) restrictions on year-round river construction work.

The useful output of this research effort is related to a hypothetical marshland erosion control operation which was developed to illustrate the economics of such a business on a local basis. Similar outlets, peculiar to the geographic area, could be used in other sections of the country. The operation described in this report indicates that under certain conditions the use of compacted automobile bodies for erosion control purpose could be a profitable venture, provided that use of the compacted hulks for this purpose can be successfully demonstrated. A basic premise in this description is that the price of scrap metal has decreased sufficiently to block the normal flow of junked automobile bodies to scrap processors. This seems to be unlikely at the present time due to the successful operation of the shredding machines.

Publications: None

EC-00276-02
(UI-00579-02)

UTILIZATION OF BARK WASTE

HARVEY AFT
OREGON STATE UNIVERSITY
CORVALLIS, OREGON

Objective: To outline a program in which the biological, chemical and physical sciences are integrated into coordinated and cooperative studies which can promote economic use of bark, thus relieving the pollution created by present methods of disposal.

Significant Results: Research has proceeded in two areas of endeavor. One is Physical Utilization, and the other is Chemical Utilization. Certain phases of the problem have required cooperation between the two groups.

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Physical Utilization. Three principal lines of research effort were maintained.

1. Bark Pelleting. Trials have been made on 15 different species of bark, or mixtures of barks, or bark plus woody residues. Good to excellent pellets of 1/4 and 1/2 inch diameter have been made in most cases. The densification factor during pelleting is 2.5 to 3; this offers a practical application in transport of bark wastes.

2. Bark Molding. Involved was a three-way cooperative relationship between a lumber company, a plastics company, and the School of Forestry. Dry comminuted bark was prepared and the lumber company financed the plastics plant machine time. Several types of extruded, sheet formed and injection molded products have been produced on commercial machines, with bark extension of the plastic in the order of 40-60 percent. Preliminary economic analyses appear favorably inclined toward commercial application.

3. Cooperative Efforts. Samples of bark or bark fractions were prepared for a number of forest products, engineering or other companies interested in use of this raw material.

Chemical Utilization. Investigations of the detailed chemical composition of Douglas-fir bark has included the following:

1. Hexane Soluble Wax. The fraction contains two long chain fatty alcohols and phenolic-like compounds.

2. Benzene Soluble Wax. The fraction contains two compounds which have a pleasant aromatic odor.

3. Bark Carbohydrates. (a) The inner bark of Douglas-fir was successively extracted with 80/20::ethanol/water; 2/1::benzene/ethanol, hot water, dilute ammonium oxalate, and acidified sodium chlorite.

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(b) The 80/20::ethanol/water extract (15.4 percent of inner bark) contains a trace of glucose.

(c) The 2/1::benzene/ethanol extract (3.0 percent of inner bark) contains no free sugars.

(d) The water extract (8.6 percent of inner bark) contains glucose and several amino acids.

(e) The ammonium oxalate extract (3.8 percent of inner bark) contains no free sugars.

(f) The holocellulose (46.2 percent of the bark) is the delignified carbohydrate portion. It contains glucose, mannose, arabinose, galactose, and xylose.

4. Ammoniated Bark. Treatment of bark with gaseous ammonia increased the nitrogen content from 0.46 percent to 4.08 percent. The treated bark is being separated by various solvent extractions.

Publications: None

EC-00277-02
(UI-00585-02)

SOLID WASTE DISPOSAL AND BIRD HAZARD TO AIRCRAFT

HOWARD L. COGSWELL
CALIFORNIA STATE COLLEGE
HAYWARD, CALIFORNIA

Objectives: To study the factors emanating from solid waste disposal by various landfill methods that have significant influence on the kind, the degree, and the daily and seasonal timing of hazard to aircraft through collision with birds.

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Primary attention is being given to the San Francisco Bay area to disposal sites that attract gulls or other water birds, blackbirds and starlings, and to the patterns of movement of these birds to and from disposal sites and through the critical airspace of relevant airports. After the essentials of such pattern are determined for several airports and ecologically related disposal sites, experimental alteration of sanitary landfill disposal methods and/or subsequent treatment of the newly filled land will be undertaken.

The goal of these experiments is to discover feasible ways of reducing the collision hazard.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

EC-00278-02
(UI-00594-02)

LASER MEDIATED LIGNIN SOLID WASTE FERMENTATION

DONALD A. KLEIN
OREGON STATE UNIVERSITY
CORVALLIS, OREGON

Objectives: To obtain data on the effects of lasers and irradiation energy sources on the configuration of lignin substrates, and to evaluate effects of such modifications on microbial transformation and degradation processes. By modifying the secondary and tertiary structures of lignin substrates in aqueous solution, with use of laser energy, as part of a continuous microbial fermentation, it is planned to develop processes by which the lignin polymer can be degraded completely, for use as a carbon source, or be modified by microbial transformations to yield chemical intermediates of commercial interest.

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EC-00278-02 (Continued)

Significant Results: Definite improvement of ligninsulfonate biological availability by use of photooxidative modification has been shown.

Work with both fungal and bacterial growth systems in pure cultures has indicated that photolysis during low or high pH conditions, in comparison with pH 7.0, permits retention of a greater portion of ligninsulfonate carbon. By use of varied photo-oxidative conditions, it has been possible to render residual ligninsulfonate carbon up to 70 percent bio-utilizable. Without photolytic modification negligible bio-utilization is observed.

Research of this period has also given information germane to the present and future design of lasers to be used in such processes. Light wavelengths of under 210 nm are required, and as little as 0.5 Watt of output power should give the potential for an efficient single-pass treatment system.

Information on the nature of biological responses to photooxidized ligninsulfonates has also been obtained. Fungi appear to utilize lower-weight polymeric products produced earlier in photomodification as well as aromatic lignin subunits, while bacterial responses appear to be related primarily to the utilization of aromatic subunits produced in later stages of the photooxidation process. Microbial economic utilization coefficients with photolytically-produced ligninsulfonate fragments can be equated to use of conventional carbon sources. Model compound studies using alpha-conidendrin have confirmed accumulation and utilization of aromatic subunits derived from photolysis.

Further applications of this research can be considered based on presently available information. Such biologically improved ligninsulfonate will be amendable to efficient degradation in waste treatment plant and lagoon systems, and also will be available for production of single-cell protein. In addition, this treatment approach

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can be applied to diverse lignin-containing materials, and also to pesticides and chemical wastes.

This solid waste utilization approach can become a major factor in creative recalcitrant waste product management.

Publications: None

EC-00279-02 (UI-00597-02)

KINETICS OF PORTEOUS REFUSE HYDROLYSIS PROCESS

ALVIN O. CONVERSE
DARTMOUTH COLLEGE
HANOVER, NEW HAMPSHIRE

Objectives: The long range objective is to devise and design processes for refuse disposal which are more desirable than the ones currently available. Several possible processes have been examined and it has been found that the production of ethanol via hydrolysis, fermentation and distillation from the cellulose-containing material present in refuse is attractive.

The hydrolysis step is of crucial importance and at present the kinetics and resulting yield of fermentable sugars must be inferred from some limited studies done on wood. As a first step therefore, it is proposed to study the hydrolysis of the cellulose-containing material found in refuse, and to carry out the corresponding reactor design. If this work yields satisfactory results it will be necessary to study the fermentation and distillation steps since the effect of the various materials found in refuse is unknown.

Significant Results: Evaluation was made of the possibility of recovering the paper in refuse as sugar by acid hydrolysis. Saeman's data was used on the acid hydrolysis of cellulose in wood and showed that an economic process is possible when the sugar is

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converted to alcohol by fermentation. Thus a municipality can obtain revenue on the sale of alcohol to offset the cost of collection.

Since one of the major factors in the economic feasibility of this process is the yield of sugar obtained by the hydrolysis, the initial objective was to obtain the kinetics of the reaction given the yield of sugar as a function of temperature (180° to 230°C) and acid concentration (0.2 percent to 1.0 percent H_2SO_4) for (kraft) paper instead of wood. With these results a preliminary plant design was completed which can produce sugar at a cost of 1.8 to 3.0 cents per pound--a range which is competitive with sugar from molasses.

The exact economics of a hydrolysis plant depend on a number of factors which vary from locality to locality. The design is presented with a computer program which simulates the plant performance and economics for a given set of conditions. The major factors affecting the economics are the plant capacity, the percent cellulose in the refuse, and the charge, or dumping fee, if any, for processing the refuse. The plant operation conditions can also affect the economics. The most significant variable is the liquid to solid ratio for the paper slurry fed to the hydrolysis reactor. While a ratio of 10 to 1 was used in the laboratory equipment, smaller ratios lower the cost of operating the plant.

Currently a small scale continuous acid hydrolysis reactor is being built to explore further the effect of the operating parameters on the economics of the plant design. While the cellulose in actual refuse samples has been converted to sugar, the effects of the impurities on the yield of sugar and on the subsequent fermentation are being studied.

Publications: None

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EC-00281-01 (UI-00611-01)	DECISION MAKING AND SOLID WASTE DISPOSAL	JOHN R. SHEAFFER UNIVERSITY OF CHICAGO CHICAGO, ILLINOIS

Objectives: The overall objective of this project is to facilitate the location of solid waste disposal facilities in urban areas. This research will seek to increase understanding of the decision making process as it relates to the disposal of solid wastes and to analyze the attitudes which influence the processes.

This grant assists in the formulation of a strategy for locating solid waste disposal facilities. This strategy will be designed to improve the comprehensive planning process as it relates to solid wastes. If the research bears out the need and feasibility, public educational materials will be prepared to assist in bringing about attitudinal changes regarding the disposal of solid wastes. Such changes would be basic to more pragmatic, straightforward decisions on the selection of solid waste disposal sites.

Significant Results: An interdisciplinary research team was organized to carry out the research tasks. A seminar on solid wastes was organized and conducted. The seminar format was a series of round-table discussions on issues and problems relating to solid waste disposal decisions. The seminars provided a common base of information and understanding for the researchers. Speakers at the seminars included both private operators and public officials. The informal structure provided insight into the decisions commonly associated with solid waste disposal. In association with the seminars, thorough reviews of the psychology, economic, and planning literature were undertaken to provide a meaningful base for this research effort. The social psychology laboratory made preparations for the Wyocena, Wisconsin, field experiment--an analysis of an active decision regarding the rail haul of solid wastes. The team of economists associated with the project began to formulate economic strategy

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that could be applied to assist in the understanding of solid waste disposal decisions. An initial effort was made to identify factors that affect the costs of solid waste disposal strategies and to assemble cost information for analysis.

Publications: None

EC-00283-02 (UI-00622-02)

A RECIRCULATING WASTE SYSTEM FOR SWINE UNITS

J. RONALD MINER
IOWA STATE UNIVERSITY OF SCIENCE & TECHNOLOGY
AMES, IOWA

Objectives: To study the economic and technological feasibility of totally confined and environmentally controlled swine production units.

The objective of this research is to treat the liquid waste to such an extent as to allow recirculating the liquid effluent. This would reduce both the water requirement of the system and the water pollution potential of the discharge. The system when perfected will be a waste management system which reduces the manure handling requirements to periodic removal of biologically treated sludge for final drying or field spreading.

Significant Results: A recirculating hydraulic manure transport system was operated in a building housing 700 finishing swine. Manure is deposited by the animals in a shallow gutter which traverses the pens. Hourly, 125 gallons of treated effluent is flushed down each gutter, transporting the manure to an anaerobic lagoon. From the lagoon, effluent is pumped to a covered oxidation ditch for further treatment. After sedimentation, the oxidation ditch effluent is pumped back to the storage tanks and used as flushing water within the building.

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The result of this system is a large confinement swine building which operates with a minimum of odor, without the need for manual pen cleaning or other manure handling effort, which requires no hauling of manure, and which does not result in the discharge of pollutants to surface water. The quality of the recycled water is sufficiently good to eliminate manure odors within the building and has not resulted in decreased performance of the animals which come into contact with the flushing water.

Work continued in the application of lagoon effluent to cropland as a secondary treatment method which includes nutrient removal. Liquid application rates in excess of thirty inches per year and nitroger application rates in excess of two thousand pounds per acre per year have been mace. Under these severe conditions, discharge reaching drain tile lines was colorless, free of organic matter and significantly reduced in nutrient concentration.

As an alternative means of nutrient removal, a hydroponic system utilizing water hyacinths was considered. These plants, although of semi-tropical origin, grew well under Iowa conditions and showed potential of sufficiently removing nutrients from partially treated liquid animal wastes to produce an effluent acceptable for discharge to surface streams.

Publications: None

EC-00289-04
(UI-00693-04)

BIOLOGICAL METHANE FORMATION

MARVIN P. BRYANT
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

Objectives: The research encompasses studies of the ecology, nutrition and biochemistry of biological methane formation. The quantitatively significant bacteria,

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in important natural sites of methane formation, will be enumerated, isolated and characterized. Special attention will be given to sewage sludge digestors and the digestive tract of ruminants. Characterization of isolated methane bacteria will include nutritional studies to establish the relationship of the nutrient requirements of the organism to the chemical compostion of the natural habitat. Bacteria which produce methane from various organic substrates, hydrogen and carbon dioxide will be enumerated and isolated.

The biochemistry of methane formation in Methanobacillus omelianskii, which has already been studied in some detail, will be investigated. Other methane bacteria will also be studied biochemically to compare the mechanism of methane production in various bacteria which produce methane from organic substrates, hydrogen and carbon dioxide. Other aspects of the biochemistry of methane bacteria, e.g. electron-transport systems, biosynthesis of cell constituents, will also be studied.

Significant Results: Work has resulted in great modification of theory concerning the bacteria concerned in degradation of organic wastes by methane-fermentation. Previous information indicated methane forming bacteria produced methane by degradation of acids, alcohol and hydrogen produced from organic wastes by nonmethanogenic bacteria. It was found that alcohol is not fermented by methane bacteria but by bacteria which produce acetate and hydrogen; but these bacteria require symbiotic association of methane bacteria, which utilize the hydrogen to reduce carbon dioxide to methane, in order to degrade alcohol. The work suggests that similar symbiotic associations of methane bacteria and others may be responsible for degradation of fatty acids other than formate and acetate and emphasizes the importance of hydrogen utilizing methane bacteria in degradation of organic wastes.

Studies on nutrients essential or stimulatory to growth of two of the more important hydrogen utilizing methanogenic species show the great importance of acetate as a

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major carbon source, ammonia as the major nitrogen source and sulfide as sulfur source. These bacteria are unable to effectively utilize amino acids or peptides either as carbon or nitrogen sources. Some strains require an unidentified growth factor in very small amounts. Methods were previously developed for isolation of the factor from sewage sludge or rumen contents but could not obtain large enough amounts of factor for definite characterization. It has been found that it is produced by other methanogenic species in amounts which should make identification feasible. Establishment of nutrient requirements of methane bacteria may give information of value to development of methods for more rapid anaerobic degradation of organic wastes.

Knowledge on biochemical mechanisms by which methane bacteria reduce carbon dioxide to methane has been increased. ATP has been shown to be required in catalytic amounts for initiation of methane formation from either carbon dioxide or methylcobalimin by cell extracts. A low molecular weight methyl carrier is present in extracts and is essential for methane formation. Studies on its identity are in progress. Results so far suggest it is identical with the unidentified growth factor indicated above. A previously unknown compound involved in electron transport has been isolated.

Publications: Wood, J. M., Kennedy, F. Scott and Rosen, C. G. "Synthesis of Methyl-Mercury Compounds by Extracts of a Methanogenic Bacterium." Nature. 220(5163):173-174. Oct. 12, 1968. University of Illinois, Urbana.

McBride, B.C., Wood, J.M., Sibert, J.W. & Schrauzer, G.N. "Methylcobalt Derivatives of Vitamin B_{12} Model Compounds as Substrates in Enzymatic Methane Formation." Jo. of The American Chemical Society. 90, 5276, Sept. 11, 1968.

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EC-00292-02 (UI-00701-02)	THERMOPHILIC METABOLISM IN SOLID SUBSTRATES	MARVIN E. STEPHENSON MICHIGAN STATE UNIVERSITY EAST LANSING, MICHIGAN

Objectives: To develop a valid laboratory model of the reacting system and to measure both the macro- and micro-components of the products of the decomposition process. As an ancillary objective, this study will provide for the development and/or evaluation of analytical techniques necessary for the determination of the physical and chemical constituents related to the decomposing mass. Practical parameters of stability should also result from this investigation.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: None

EC-00297-04 (UI-00550-04)	ENGINEERING PROPERTIES OF FARM WASTES	E. PAUL TAIGANIDES OHIO STATE UNIVERSITY RESEARCH FOUNDATION COLUMBUS, OHIO

Objectives: To direct research on basic information on the properties of livestock manures, and to describe the properties of these wastes in terms which will be independent of specific handling systems and thus increase their usefulness in design. To correlate data on the manure properties with production parameters such as mean live weights, feed intake, and daily protein intake. Also by the use of computers the effects of such changes as temperature, ventilation rates, and humidity on the engineering properties of these wastes will be evaluated.

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EC-00297-04 (Continued)

Significant Results: Odor nuisance is one of the most critical problems adversely affecting livestock and poultry producers. Using an equilibration sampling technique, volatiles from dairy animal waste were concentrated into a form suitable for gas chromatographic analysis. An odor signature, the gas chromatogram with an organoleptic evaluation indicated for odorous peaks, was obtained for dairy waste decomposing anaerobically. Compounds tentatively identified as contributing to the odor were hydrogen sulfide, methanethiol, methyl sulfide, ethyl sulfide, propyl acetate and n-butyl acetate.

Agricultural land is the best alternative for the disposal of animal wastes. Using a system analysis approach, a scheduling model was developed for studying long-term scheduling decisions for removing animal waste from storage and spreading it on agricultural land. The maximum quantity which can be disposed, in each time period, is constrained by storage capacity, quantity of waste generated, and land area available for spreading. An air quality model was developed for evaluating the odor nuisance potential of animal wastes as a constraint on land spreading operations. The principal parameters affecting downwind ground level concentration of odors are emission rate, wind speed, diffusion coefficients, and turbulence index.

There exists a menace from noxious gases in animal confinement units. It was determined that under normal operating conditions gases in confined animal houses do not reach toxic or lethal levels. Toxic level may be reached during failure of the forced ventilation system or due to mismanagement practices, such as agitating liquid manure storage under the building.

Combustion of animal manures is a possible unit operation in a waste management system. Animal wastes were pyrolyzed, heated to 800°C out of contact with air. Gases, water and organic liquids are evolved, leaving a clear residue. The gases were analyzed for the percentage of CO_2, CO, H_2, illuminants (unsaturated hydrocarbon) and methane and ethane.

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In the design of biological treatment units, values on the oxygen demand of the waste are essential. In the determination of the oxygen demand parameters of animal wastes, seeding, temperature, method of determination, and type of waste have a significant effect. Storage of samples at below 2°C prior to dilution does not have a significant effect.

In the design of waste management systems, a knowledge of the quantities of waste excreted by animals is essential. The quantities of the total excrement from animals is significantly affected by the feed, the weight of the animal, and the type of the animal. The total daily manure excrement varied from around 15 percent of body weight when cows were fed silage to 6 percent when fed on corn and grass silage. Cow manure excrement ranged from 13 percent to 53 percent of the feed intake per day.

Publications: No additional publications.

EC-00302-02 (UI-00746-02)

SURVIVAL OF PATHOGENS IN ANIMAL MANURE DISPOSAL

STANLEY L. DIESCH
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA

Objectives: To study the survival and the subsequent public health significance of pathogenic bacteria in cattle manure. The systematic process of manure disposal by extended aeration will be utilized. Laboratory experiments utilizing scale models of an operational field unit will be used to duplicate and study environmental and mechanical factors of the field unit and for measurement of the effect on the survival of pathogens which can contaminate the environment and pollute the water if discharged.

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EC-00302-02 (Continued)

Significant Results: As new methods of animal manure disposal are developed, it is essential that the effect of these methods on the health of man and animal and their common environment be determined. At present leptospires (shed in urine of infected animals) are being used as the model infectious agent. Preliminary studies are being conducted on the use of Salmonellae. These organisms cause diseases that are of major economic importance in animals and are transmissible to man.

The Department of Veterinary Microbiology and Public Health is utilizing a 1:10 laboratory scale model of an operational field ditch. In the field ditch the Department of Agricultural Engineering is studying the treatment of manure from beef cattle, housed under confined conditions. The field ditch is used for storage, treatment and receives manure from 36 beef cattle. After 6 months, animals are removed and ditch residues pumped and new tests begun. Observed biological, chemical and physical data indicate a system with capacity of 50 ft. 3/animal can store and treat such wastes through the Minnesota winter period.

The operational laboratory model has been developed and is being utilized to simulate field environmental conditions to study survival and detection of seeded pathogenic bacteria in beef cattle manure obtained from the field oxidation ditch. Improved methods to measure survival and detect leptospires in the manure have been developed by the use of fluorescent antibody and artificial cultural isolation techniques. Repeated survival studies have been conducted in the manure environment of Selas porcelain candles which allow a nutritional exchange with the liquid media of the laboratory ditch. Studies have been conducted under simulated field conditions with varied pH, dissolved oxygen, temperature and total solids. Recovery of the leptospires have been culturally made up to several days following seeding. Leptospires have been found by the fluorescent antibody techniques for longer periods of time. Studies are being conducted in manure effluents of scale models of settling chambers under varying environmental conditions. Leptospiral survival has been measured for several days and detection for longer periods. These findings indicate that a

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EC-00302-02 (Continued)

definite potential health hazard exists for man and animals.

The Department of Agricultural Engineering is utilizing another laboratory scale model of the oxidation ditch. Studies are being made to define solid settlement patterns and the feasibility of the ditch as a means of separating undigested feedstuffs having nutritional value for re-use. The laboratory model has been utilized as an effective tool on changes in rotor design to control excessive foaming and effect oxidation capacity.

Publications: None

EC-00304-01 (UI-00755-01)

INCINERATION OF PLASTICS FOUND IN MUNICIPAL REFUSE

RICHARD W. HEIMBURG
SYRACUSE UNIVERSITY RESEARCH CORP.
SYRACUSE, NEW YORK

Objectives: A systematic study of the destruction of synthetic polymers, especially plastics and plastic-rich refuse by two incineration methods will be performed. The two methods are: (1) direct burning of the refuse, and (2) anaerobic heating followed by burning of the volatile matter. Of particular interest are (1) the chemical and toxicological nature of the stack effluent and (2) the interaction of the solid residue with water. The ultimate interest is in finding a process and/or set of incineration conditions which result in the destruction of plastics-rich refuse with minimum air and water pollution.

Significant Results: The principal task has been to build the two-stage incinerator and assemble a suitable analytical train to examine the several gaseous elements emanating during combustion. The basic components have been assembled at this time.

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EC-00304-01 (Continued)

A laboratory incinerator has been built to subject the refuse to conditions which approximate the conditions in a variety of incinerators. The model incinerator can be batch-fed or fed continuously; a wide variety of primary chamber and afterburner conditions are available--the temperature, time-at-temperature for the gas, degree of turbulence, etc., can all be varied over a wide range. By means of a movable probe in the afterburner, GC analysis of the gas is accomplished essentially "on-line." By so doing it was possible to trace the destruction of the more refractory compounds such as benzene and formaldehyde.

The probe used here is air cooled (from the inside). The sample is continuously drawn into its stainless steel tip and cooled immediately to a predetermined temperature--between the ice point and 200° C. The high-boiling fractions are immediately condensed in the tip of the probe. (These are later extracted and analyzed separately.) The remainder of the inducted gas is now available to a total hydrocarbon detector and a concentrator. After a given period of time a concentrated sample is fed either to the total hydrocarbon detector, a thermocouple detector, or a GC column. This yields a very flexible and sensitive system. In normal operation the sample gas is exposed only to stainless steel, aluminum oxide and pyrex glass until it reaches the GC packing. The system will accept traps using ascarite or a hydroscopic material; these are used sparingly because of the potential complications of exposing additional materials to the sample, especially in a trap (granular) configuration.

The gas which does not enter the probe is cooled to just above the dew point of its water. The fly ash is then collected and analyzed by size and composition. The gas is then diluted 15:1 by clean air and passed to animal and plant exposure chambers. The relative humidity of the exposure air can be varied from about 30 percent to 100 percent for the range of temperatures 70°F to 100°F. The response of the various animals and plants is compared to their respective control groups which are subjected to clean air only.

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The residue (usually an ash) is subjected to a spray of water. This water is then filtered and enters several aquaria to determine its effect on aquatic life. This is meant to simulate the effects of percolating rainwater.

Experiments are underway to determine calibration procedures for gas chromatographs for the gases encountered. An exponential dilution flask has been constructed to aid in supplying known concentrations of the gases.

A general purpose concentrator which will collect minute quantities of trace gases and release them upon demand to the detecting system is being designed and tested. Steps are being taken to incorporate in the analysis sequence, flexibility for the detection and reproducible analysis of the effluent gases. Construction of flow systems and establishment of steady-state flow conditions has occupied much of the chemical analytical effort. Drift and low signal/noise ratio are serious deficiencies which must be overcome to initiate significant analyses of low concentrations of certain gases in the effluent.

In order to undertake toxicological studies with plants and mammals, exposure chambers have been constructed. Their connection to the stack of the incinerator is under construction.

Publications: None

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EC-00309-01 (UI-00828-01)	MATHEMATICAL ANALYSIS OF SOLID WASTE COLLECTION	JON C. LIEBMAN JOHNS HOPKINS UNIVERSITY BALTIMORE, MARYLAND

Objectives: The collection and disposal of solid wastes is one of the most pressing problems faced by cities, and consumes a major portion of municipal budgets. A first step in the systematic analysis of collection systems has been made in the large scale simulation models built by Truitt, Liebman, and Kruse. This proposed research is a logical extension of the previous work, making use of mathematical techniques to determine optimal location of transfer stations and to investigate the effect of optimal policies of changes in parameters. The work will make use of the data gathered by the simulation study for Baltimore City, and will also use the simulation models as checks on the analytic solutions.

Significant Results: In line with the objective three different models have been formulated, and their applicability to the solid waste collection problem explored in detail. Sensitivity analysis has been used in conjunction with the models to determine the relative importance of various parameters.

The first model is an attempt to determine optimal locations for collection facilities, with particular interest centering on transfer stations. This problem has been formulated as a capacitated transshipment problem, and is solved with a combination of the out-of-kilter algorithm and implicit enumeration. After testing with several artificial data sets, the codes algorithm was used to analyze possible transfer facilities in the northwest quadrant of the City of Baltimore. (The Northwest quadrant of Baltimore was used for analysis because of the ready availability of data, and because it has been used in the earlier study by Kruse, Truitt, and Liebman.) The results verified the earlier findings of Truitt et al. indicating that for this area a transfer site is marginal. The same algorithm was used to test the

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feasibility of rail-haul, and to explore costs of increased collection frequency. Rail haul was found to be infeasible. Cost was found to increase only 4.5 percent for changing collection from two to three times per week, under the assumption that the per-capita generation of waste remained unchanged; however, costs increased quite rapidly if the amount of waste generated increases. This result is particularly important in the light of the findings of Quon et al. that waste amounts increase significantly when collection is increased.

The second and third models both deal with the routing of vehicles. One is an extension and generalization of Szwarc's multi-commodity truck assignment problem for a common vehicle fleet. The model is solved directly by an out-of-kilter algorithm, and may have applicability where several types of waste are collected. The other routing model is a formulation of the M-salesman traveling salesman problem. An implicit enumeration scheme is used for solution. This model can be used for detailed routing of collection vehicles, block by block.

Publications: None

EC-00316-02 (UI-00872-02)

EFFECTS OF PROCESSING POULTRY MANURE ON DISEASE AGENTS

JAMES R. HOWES
TEXAS A & M UNIVERSITY
COLLEGE STATION, TEXAS

Objectives: Poultry feces will be either composted or dried and the effects of these processes on the carryover of disease agents to the end product will be studied, with and without the aid of disinfectants. Agents to be tested will include some of the more common and important ones of the various types: Newcastle disease virus, infectious bursal agent, fowl pox virus, leukosis complex (2 viruses), PPLP, Salmonella gallinarum, parathphoids (1 sp.), Pasteurella multocida, Aspergillus sp. (flavus), Eimeria sp., Ascaridia galli, Raillietina cesticillus,

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Bdellonyssus sylviarum and the darkling beetle. Also, selected type ogranisms of other animals and man will be tested. Intermediate and end products will also be chemically analyzed in order to learn more about the processes so that this information may be applied to the control of disease agents in these processes. The effect of various physical factors such as air, moisture, temperature on the end product will also be studied in efforts to control disease agent carryover. The control of atmospheric pollution with fomites and odors provided by products of these processes will be measured.

Significant Results: Reduction in the volume of poultry wastes: Traditionally all floor raised commercial poultry-broilers, turkeys, most replacement pullets, and many layer flocks are raised on fresh floor litter. By composting the litter between broods it has been demonstrated that the heat treatment controls most active pathogens and the volume of litter required by the poultry industry has therefore been greatly reduced. This is of economic benefit to the poultry industry especially as competition increases for sugar cane wastes, wood shavings, and other absorbtive materials.

From the standpoint of the volume of poultry solid wastes it is estimated that 90 percent of the broilers and many of the turkeys raised during the past 2 years in the USA have been raised on recycled litter, thereby vastly reducing the volume of solid wastes for disposal. Furthermore, the resulting stabilized organic wastes do not pollute soil, water, and air when distributed on the land as does raw manure.

Manure from caged poultry: Due to labor shortages and economics many poultrymen are presently being forced to automate their layer operations by caging their birds. Aerobic digestion of caged layer poultry manure has been economically established and is now being used on a limited scale in the USA to combat fly and odor problems. Aerobic digestion will control these problems and has enabled some harassed poultry

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operators to remain in business. In addition the volume of the manure has been greatly reduced and furthermore stabilized organic material eliminates soil, water and air pollution.

Cages for broilers: Broilers classically are raised on floor litter to avoid the development of breast blisters and leg deformities. Recent studies under this grant have shown that broilers may now be raised successfully in plastic floored cages without these problems. If the cage system is adopted for raising broilers by the poultry industry, and it could well be the case, the volume of solid wastes produced by broilers in the USA could be further vastly reduced since no litter would have to be used. The feces could also be digested under these cages to reduce volume, control fly and odor problems and stabilize the material to avoid odor, fly and pollution problems when it is used in horticulture and agriculture.

Composting of cattle feedlot wastes: Although outside the limits of the grant, assistance has been given to a feedlot operator in Texas to compost feedlot wastes. A pilot operation has been highly successful producing a reduction in volume and resulting in an odorless stabilized agricultural fertilizer.

The limitation of laboratory composting of poultry wastes has been clearly demonstrated. It is necessary to have adequate volume in order to simulate field conditions. The results obtained from small units are highly suspect, at least 100 bird units being necessary to afford adequate volume.

Disease carryover in composted poultry wastes: Studies with Coccidia, Salmonella, and Newcastle virus seeded in litter prior to composting indicate reduction in active pathogens. Due to overlong composting resulting from inadequate sized litter piles the same reductions in pathogen numbers were obtained with time. It is essential therefore to have sufficiently large piles of manure when composting in order to obtain adequate heating.

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(Continued)

Recent studies indicate several species of bacteria and viruses are not suitable for a variety of reasons for studying the carryover of disease agents in poultry wastes. Coccidia and nematodes appear to be the best agents with which to work, especially since these agents are not highly contagious. Techniques developed to control these agents would probably be effective for others, since these organisms are relatively difficult to control.

Ultraviolet irradiation of poultry manure has been indicated to have distinct possibilities in controlling the carryover of disease organisms.

Publications: None

EC-00317-01
(UI-00873-01)

ENGINEERING PROPERTIES OF COMPACTED ASH FILLS

DONALD H. GRAY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

Objectives: The objectives of the proposed research are twofold: 1. To investigate the engineering properties of compacted fly ash and incinerated sewage sludge for use in structural fills.

2. To investigate possible health or environmental hazards posed by such usage.

The annual production of fly ash or ash from incineration of sewage wastes poses a serious disposal problem. An effective solution would be to use this material for fill purposes...not only as a light weight backfill but also as a structural fill or subgrade capable of supporting heavy loads.

In order to use these ashes successfully for such purposes, their chemical, physical, and engineering properties must be determined. The problem requires an interdisciplinary approach because soil mechanics are involved on the one hand and sanitary or environmental engineering on the other.

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EC-00317-01 (Continued)

Significant Results: Two different types of ashes are being investigated, viz., fly ash from the combustion of coal and hearth ash from the incineration of sewage sludge. The former has been obtained from various coal fired power stations in Michigan, and the latter, from municipal treatment plants all over the nation.

The fly ash study is focusing primarily on the frost susceptibility and compressibility of the ash after it has been compacted. It is clear that these two properties are probably the most critical with regard to acceptance of fly ash as a replacement aggregate for road subbase or structural fill.

The hearth ash (incinerated sewage sludge) study is much broader in scope. An effort is being made to characterize this material as completely as possible by relating its engineering behavior (when compacted) to its chemical composition, mineralogy, and such index properties as grain size distribution. In addition, an investigation is being made of possible adverse effects of this material such as its aggressiveness towards metals, vegetation, COD, etc.

A determination has been made of the index properties and completion made of the preliminary strength-compaction studies on the majority of the fly ashes and sewage ashes that it is intended to investigate. A frost heave test apparatus has been designed and constructed, and is now ready for use. Recent thought has been given to the age-hardening properties of compacted ash samples and the effects of low level additions of lime and cement on their engineering behavior. Pilot tests have shown that low level additions of lime or cement to some ashes followed by static compaction to 5000 psi plus moist curing (or autoclaving) will produce a material with remarkably high strength.

Publications: None

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EC-00319-01 (UI-00876-01)	WOOD WASTE REUSE IN CONTROLLED RELEASE PESTICIDES	G. GRAHAM ALLAN UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

Objectives: To study the possibility of chemically bonding certain pesticides with solid wastes so that the bonded pesticides will be released slowly over a long period of time and thereby enhance their effectiveness at a lower concentration than if used alone. The solid wood-waste such as bark, pulping wastes and screenings, lignin and sawdust will be employed as substrates to which pesticides will be chemically attached to afford inactive solid waste-pesticide combinations. These combinations will be so designed as to permit the use of new more transient and readily metabolized pesticide materials. The four specific aims are to study how:

1. Pesticides can be chemically attached to solid wood and agricultural wastes;

2. The solid waste pesticide combinations break down in the soil;

3. The rate of release of pesticides can be controlled by the selection of the solid waste substrate and the amount of the pesticide attached; and

4. Pest problems can be alleviated by these solid waste pesticide combinations

Significant Results: Among the many advantages which can be anticipated from this work are the utilization of solid waste and a reduction in the quantities of pesticides being haphazardly distributed. In the initial phases concern was with the use of such combinations to reduce the adverse effect of the rapid growth of brush on the slower growth of young conifers. The first step towards the realization of this goal is to synthesize solid waste-herbicide combinations and to determine their relative toxicity to conifers and to brush. A number of such herbicide combinations with bark and lignin from waste pulping liquors have been prepared and analyzed

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using the Nuclear Reactor facilities of the University of Washington. A greenhouse has also been set up and conifers and their competitors have been planted. In a few weeks time it will be possible to begin biological evaluation of the effectiveness of the controlled release solid waste-herbicide combinations.

Publications: None

EC-00324-01 (UI-00907-01)

NATIONAL CONFERENCE ON PACKAGING WASTE MANAGEMENT

GEORGE F. STEWART
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA

Objectives: The objective of this project is to have a nationwide conference to explore, evaluate, give direction to, and stimulate research and discussion on packaging wastes management. About 12 percent of the total residential, commercial and portions of industrial rubbish which must be disposed of is discarded packaging material. All aspects of packaging--appeal, convenience, protection, cost, advertising--encourage the use of materials, especially non-ferrous metals, plastics and glass which are wholly or partially indestructible by the natural processes of biodegradation, corrosion and oxidation. Thus, the packaging component of solid wastes represents an increasing disposal problem in that present conventional methods are not totally effective, practical or suitable.

In-depth consideration must be given to what is now to be done, what is presently known, how to do technologically, but is not being done, and why it is not being done. Keeping the above in mind, there is the need to explore the rapidly changing nature and dimensions of the problem. The solution to this problem will require a multi-disciplinary approach, involving technological, economic, political and social considerations. This approach suggests that public agencies, industry and University

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personnel concerned get together for the purpose of gaining a mutual understanding of the problem, and to chart ways for its solution that are realistic for all concerned.

A national conference was held on September 22-24, 1969 on the Davis campus of the University of California. Between 300-500 knowledgeable and interested professional people, representing the broad fields effected and concerned, found the program both challenging and informative. The program offered guidance and direction, but of even more importance, acted as a catalyst to stimulate research and education. A conference proceedings will be published.

EC-00325-01 (UI-00910-01)

FIRESIDE METAL WASTAGE IN MUNICIPAL INCINERATORS

PAUL D. MILLER
BATTELLE MEMORIAL INSTITUTE
COLUMBUS, OHIO

Objectives: The objectives of this research program are to identify the conditions leading to fireside metal wastage in solid waste incinerators, to determine the mechanisms by which metal loss occurs, and to devise corrective measures. Both field and laboratory studies will be made to provide data on the environmental conditions to which metal surfaces are exposed in incinerators, and the effect of these conditions on metal wastage. This will involve measurements of such operating variables as flue-gas composition, temperature, and velocity, of heat transfer rates, of metal temperatures, of dust loading, and of the composition of deposits laid down on metal surfaces. These many factors will be related to the rate of metal loss, to the characteristics of the refuse being burned, to the rate of incineration, to combustion conditions, and to differences in incinerator design. Means of alleviating metal wastage also will be investigated, by considering changes in construction materials and in furnace configuration, the use of additives, modification of combustion procedures, the burning of supplementary fuels, and controlled mixing of solid wastes.

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Significant Results: Speciments of boiler tube deposits and sections of corroded boiler tubes have been obtained from an operating incinerator for metallurgical examination and chemical analysis. The presence of lead, zinc, and chloride in the deposits is the most significant difference noted to date between the deposits from incinerators and those commonly encountereed in coal or oil-fired boilers.

Field studies using a corrosion probe constructed from four alloys are being carried out in an operating municipal incinerator in Ohio. Samples of the flue gases from this incinerator taken on different days have been carefully analyzed.

The most significant difference in the flue gas from this unit as compared to a power station was the presence of significant quantities of HCl, which probably results from the burning of certain types of plastic materials.

Laboratory studies designed to provide controlled conditions for investigating corrosion of boiler-tube materials by flue gas mixtures and boiler deposit components have been initiated. Synthetic flue gases consisting of typical mixtures encountered in incinerators are being used with SO_2 and HCl to study corrosion of the same metals used in the probes. The metal specimens are in contact with compounds suspected of being the corrosive agents. Experiments to date have demonstrated that the corrosion by the flue gases alone is slight. However, when the metal is in contact with a boiler deposit component such as lead chloride, corrosion is accelerated. (Lead and chloride have been found in boiler tube deposits.) When the temperature is high enough to melt the lead chloride, the corrosion of the steel becomes severe.

Publications: None

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EC-00326-01 (UI-00912-01)	CONVERTING INCINERATOR RESIDUE TO USEFUL MATERIALS	BANI R. BANERJEE FRANKLIN INSTITUTE PHILADELPHIA, PENNSYLVANIA

Objectives: Solid waste disposal, even in the form of municipal incinerator residue is a mounting problem in our society. To convert these residues to a more useful form, FIRL has proposed a feasibility study of a new integrated approach to direct calcination, melting and slagging of the residues to produce more dense aggregates. The residues will be directly transferred from the incinerator grates into a calcination/melting furnace, thus conserving the heat in the residue and reducing the volume of effluent gases. Also the method envisions low-cost compositional control of the melt to produce an optimized product. Furthermore, it can be directly tied into existing and new municipal incinerator operations; and the same air-cleaning equipment may be efficiently utilized to clean the effluent gases from the calcining/melting unit; also, less nitrogen oxides may be expected from this process. As a result of this program, parameters will be developed, which will allow recommendations for the optimum burning and calcining conditions for the incinerator residues so that the final product becomes a useful engineering material for a road surfacing aggregate, for road building, or for other structural uses, thereby effectively recycling these wastes into useful applications. Furthermore, since most municipalities are involved both in waste disposal and in road building programs, a direct path to the recycle operations may be envisioned, and indeed two major cities on the Eastern Seaboard have expressed a keen interest in this program and have volunteered active participation and collaboration in the effort.

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EC-00326-01 (Continued)

Significant Results: Philadelphia incinerator ash has been ground, fired and milled to produce a ceramic oxide powder. An analysis for important elemental content has been made. It has been shown that this powder has thermal properties expected for the analyzed composition in terms of sinterability, fluxing behavior, etc. both alone and with additives. It is possible, from these studies, to produce a very high grade ceramic material which might be used for bricks or as a facing material.

In addition, extensive studies with additions of lime and subsequent firing have demonstrated the feasibility of turning the solid waste into cement powder and ultimately some form of concrete. Not only can the incinerator waste form the concrete mix, it may also possibly be used as a aggregate filler.

Ash has been given three different thermal treatments to produce aggregates for possible road use as well as for concrete. Testing is currently underway and the assistance of the Department of Transportation, State of Pennsylvania has been solicited on rapidly extending this development to include the testing of a piece of road after appropriate tests for friability, chemical stability etc. on the aggregate have been run. This is the most promising immediate use because the cities that produce solid wastes are also in the business of road building and topping; therefore, problems of logistics and economics are very pertinent and this use involves probably the least changes in present policies. Hopefully, later the more remote possibilities can be brought to fruition once at least one scheme for usage is under way.

It is hopeful that these studies can lead to ways of usefully using the rapidly increasing amounts of solid wastes being generated in urban areas.

Publications: None

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EC-00328-01 (UI-00919-01)	SINGLE CELL PROTEINS FROM CELLULOSIC WASTES	CLAYTON D. CALLIHAN LOUISIANA STATE UNIVERSITY & AGRICULTURAL & MECH. COLLEGE BATON ROUGE, LOUISIANA

Objectives: Due to the rapid increase taking place in the Nation's and the World's population, serious pollution problems and shortage of food will have to be overcome. Cellulosic wastes from agriculture, industries and municipalities constitute a major portion of the solid wastes, and these wastes can be converted to useful products. One of the most important products to which it can be converted is protein. Protein is the component in food and animal feed that is in shortest supply.

A versatile, continuous, chemical-microbial pilot unit is under construction. On completion it will be able to process a multiplicity of cellulosic wastes, converting them to single cell protein using an organism that has already been isolated in the laboratories. Studies will be conducted with the pilot unit to evaluate the various cellulosic wastes as substrates for microbial growth and to determine the optimum conditions for economic operations. Also, other cellulolytic organisms will be investigated for their substrate specificity. As an integral part of the project the nutritional value, digestibility and toxicity of the single cell protein product will be determined. Studies will also be conducted to direct the product improvement.

Significant Results: A new $200,000 pilot plant has been constructed at NASA-Mississippi Test Facility to demonstrate the possibility of converting the cellulosic portion of urban solid wastes to microbial proteins for animal feed. Celluosic wastes are initially ground through a knife grinder and then immersed in hot 2 percent alkali solution. The excess alkali solution is then squeezed from the cellulose which is subsequently conveyed through an oxidation chamber where heat and air cause oxidation of the lignin and cellulose mixture. The oxidized composite is then neutralized and reslurried with nutrients and fertilizer solution before being pumped to a continuous fermenter. The cellulose serves as the carbon substrate for growth of

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Cellulomonas, a cellulolytic bacterium. The residence time in the fermenter is about 2 hours. The effluent from the fermenter goes to a settling tank where undigested cellulose is skimmed off the top. The underflow stream is acidified to a pH of 4.5 which causes the microbial cells to flock and settle while the lignin is insolubilized and comes to the surface for skimming. The underflow from the second settler is then fed to a drum drier. The product is a brownish flour containing 50 to 60 percent protein. The amino acid profile of the protein shows it to be superior to soy bean flour. Production costs are estimated at 6 to 7 cents per pound.

Feeding studies are now underway on rats, chickens, swine and cattle. Also underway are studies on using newspapers, cardboard, excelsior, grass etc., as the cellulose source. Limited studies on newspapers have shown that this will serve as the carbon source for microbial growth if the paper is first de-inked using dilute caustic followed by a washing step.

Publications: None

EC-00329-01
(UI-00938-01)

USE OF DOMESTIC WASTE GLASS FOR URBAN PAVING

WARD R. MALISCH
UNIVERSITY OF MISSOURI
COLUMBIA, MISSOURI

Objectives: The purpose of this project is to establish that crushed domestic waste glass can be used as a aggregate in bituminous mixtures for street maintenance and to provide the engineering data necessary to permit the most effective use of glass in this manner. Laboratory tests and field installations will be used to establish suitable gradation ranges for the glass aggregates, and the optimum type, grade and amount of asphalt to be used. The field installations would also indicate any modifications in normal placing and compacting procedures which might be necessary due to the unique properties of glass aggregates.

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By demonstrating the feasibility of using crushed waste glass as aggregates in bituminous mixtures, a practical and efficient method of handling one component of urban refuse would be provided. This would encourage the productive use of waste products and perhaps suggest other means for utilization of such products.

Significant Results: Studies have been aimed at establishing a gradation for the glass aggregate which could be used in bituminous concrete designed to satisfy Marshall Method design criteria. The Marshall Method is one of the most commonly used procedures for designing bituminous concrete mixtures. It was found that bituminous mixtures satisfying Marshall design criteria could be designed using aggregates composed entirely of waste glass.

A test strip was placed in Toledo, Ohio, using a mixture of glass aggregates, a small amount of masonry sand and asphalt. Owens-Illinois, Inc. cooperated in the construction of this test strip by supplying the glass, the bituminous contractor who placed the glass-asphalt mixture and the site for the installation which was the entrance to their technical center. While the amount placed was very small compared to most paving jobs, this project demonstrated that conventional mixing and placing methods could be used for glass-asphalt mixtures.

Studies at the University of Missouri-Rolla are currently investigating several other aspects of the problem. Several anti-stripping agents are being studied to improve the bonding between asphalt and glass in the presence of water. Skid resistance studies will soon be initiated on test patches which have been placed on University parking lots.

Publications: None

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EC-00330-01 (UI-00948-01)	CRITERIA FOR DESIGN AND CONTROL OF INCINERATORS	ADEL F. SAROFIM MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS

Objectives: Major problems in operating modern incinerators are the difficulties of monitoring the adequacy of the residue burnout and of adjusting air flowrates to compensate for variations in refuse quality and quantity. An experimental study is proposed of the combustion on a stationary fuel bed simulating a section of a travelling-grate stoker. Detailed measurements will be made of compositions and temperatures in and above the burning fuel bed and the infrared transmittance across the top of the bed. The major objectives are (1) to obtain an easily monitorable indicator of residue burn-out of the bed which can be used in a feed back control of the air flow rates or grate speed, and thus maintain satisfactory operation and reduce labor costs; and (2) to obtain design data for optimization of air distribution to the various sections of the grate. Parallel to the above experimental study it is proposed to develop a semi-empirical mathematical model which can be used to extrapolate existing data to new conditions of operation or design. This model will almost certainly require as part of its input the design of other idealized experiments than those described above.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

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EC-00331-01 (UI-00950-01)	NATIONAL INDUSTRIAL SOLID WASTE MANAGEMENT CONFERENCE	H. NUGENT MYRICK UNIVERSITY OF HOUSTON HOUSTON, TEXAS

Objectives: The University of Houston, Cullen College of Engineering, is proposing to develop and conduct a national conference on the management of industrial solid wastes. The scope of coverage of technical information of this conference will be the characterization, collection, processing, and reuse technology of industrial solid wastes in a multi-session format. Economic considerations and secondary industry technology aspects of the problem will be considered where possible. The technical program will be developed by a national task force program committee representing various industrial, professional, governmental, and research interests. All technical papers will be requested and, if possible, will represent the most rigorous evaluation of the current technology and the state-of-the-art. Either a pre-print or proceedings book will be prepared for national professional use.

EC-00332-01 (UI-00952-01)	STANDARD TEST PROCEDURES FOR MUNICIPAL SOLID WASTE	RUSSELL H. SUSAG UNIVERSITY OF FLORIDA GAINESVILLE, FLORIDA

Objectives: The objective of this project is the development of a set of standard test procedures for the physical, chemical, and biological examination of municipal solid wastes.

These standard test procedures are necessary for the characterization of municipal solid wastes for use in the design, operation, and environmental control of the collection, storage, transport, processing, and disposal of municipal solid wastes.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00332-01 (Continued)

Analogous standard procedures have been developed and have proven essential in the control of other areas of environmental pollution and control (i.e., water, air, milk, food, and general sanitation).

It is the aim of this project to identify and evaluate existing test procedures, identify shortcomings, and recommend improvements to existing methods and development of new test procedures.

This project also proposes the establishment of an Advisory Committee on Test Procedures for Municipal Solid Wastes consisting of representatives of the U.S. Public Health Service, Bureau of Solid Wastes Management and the technical associations and societies concerned with solid wastes management (ASCE, APWA, APHA, ASME). This committee would provide guidance during the course of the project and continue as the directing body in the development and dissemination of standard test procedures for municipal solid wastes.

Significant Results: An extensive survey of the literature of the solid wastes field is being conducted in accordance with the first aim of this project: The identification of procedures and analytical methods being used in the characterization of municipal solid wastes for the design and operation of processing and disposal facilities and the evaluation of environmental pollutional effects.

State and area agencies for solid waste planning and active researchers in the solid waste management field are being canvassed to determine what test procedures are presently being used and to identify areas where methods of analysis need to be developed for the characterization of municipal solid wastes.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00333-01 (UI-00968-01)	REFUSE RECLAMATION BY SIZE REDUCTION AND SEPARATION	DAVID G. WILSON MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS

Objectives: The principal aim of the work proposed is to demonstrate the feasibility of separating refuse into several components in an automated manner. A further aim is to investigate the use of a vortex classifier mill to effect both size reduction and coarse separation. A subsidiary aim is to determine which components of refuse may be separated with maximum benefit-cost ratio.

It is planned to design test rigs which can form the basis for a small scale prototype plant.

Significant Results: Since starting work on an investigation of methods of size reduction and classification of municipal solid wastes, a number of concepts have been investigated, three of which hold considerable promise for the future.

The first of these concepts is that of obtaining a signature of individual pieces of refuse. The signature, in this case, is the reading given by an accellerometer attached to a hard-steel ball which is dropped on to the piece of refuse. Even with refuse as received it was found that the shape of the acceleration time curve is markedly different for wood, paper, aluminum cans, glass bottles, and so forth. In the next stage all refuse may be passed through rollers to flatten all items except bottles, giving more consistent readings.

The second concept which shows some promise is to measure the attenuation of short-wave-length (3-centimeter) electromagnetic radiation, through a beam of which specimens of refuse are passed. The attenuation is greatly different for different materials, but since the reading is "one-dimensional", there is nothing to distinguish between

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS,	PRINCIPAL INVESTIGATOR & LOCATION

EC-00333-01 (Continued)

a thin sample of highly attenuating material and a thick sample which is more transparent. To overcome this problem, the attenuation from several wave lengths may be measured to reduce or eliminate the thickness influence. In any case, the method shows promise as a way of detecting moisture-absorbent samples from other refuse, since water attenuates this radiation markedly.

The third concept worthy of mention is the vortex pulverizer and classifier. A small model pulverizer has been used which was made for the pulverization of coal. For it to work effectively on such different materials as textiles, paper, and glass, knives and fixed anvils have been added to the circumference. The output from this small gadget is a variety of powder and woolly fiber. The first tests have shown that it is possible to obtain a large measure of separation of the paper from the textiles and from the aluminum foil and from the glass in this one machine. However, it has not yet been shown that the operation on completely unsorted refuse would be either economical or satisfactory, since the effect of, for instance, a steel bolt is to dull the knives, while the anvils used to break up brittle materials have little effect on either the textiles or the hard, tough materials, such as steel. The pulverizer might therefore be very effective if either used solely for glass or fibrous materials, or alternatively when used on mixed materials after metals have been removed by existing procedures.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00399-01 (UI-00895-01)	HIGH ENERGY GAS FROM REFUSE USING FLUIDIZED BEDS	RICHARD C. BAILIE WEST VIRGINIA UNIVERSITY MORGANTOWN, WEST VIRGINIA

Objectives: To provide an orderly and systematic investigation into the gasification of wasted solids for the production of high energy content gas.

Several alternative processes are available for the recovery of the energy content of refuse in a fluidized bed, namely complete combustion, incomplete oxidation, and pyrolysis. In the first of these, the energy is thermal, recoverable from the bed or from the stack gases. In the latter two cases, the gas has a heating value and may be burned. In the last instance, pyrolysis, the gas should be suitable as a feed to a water gas shift reactor and then to a hydrogasification for the production of methane. This research will furnish the scientific foundations necessary for the classification of these possible alternative schemes in order that responsible engineering-economic analysis can be made of the application of one or more of these systems for reducing the costs and problems associated with the disposal of a wide variety of wasted solids.

The research will be directed to the development of data required for the design of pilot plant for the more promising alternatives. The design of these pilot plant programs is part of the project objectives.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00005-03 (UI-01009-03)	SOLID WASTES ENGINEERING	WILLIAM W. SHUSTER RENSSELAER POLYTECHNIC INSTITUTE TROY, NEW YORK

Objectives: This program provides the opportunity for well qualified-students to pursue a specialized course of study at the Master's level. While the program is administered through Environmental Engineering and is centered around a core of courses in that curriculum, the program is flexible enough to allow the selection of supporting courses drawn from the offerings of the various departments of the Schools of Science, Engineering, Management, and Humanities and Social Sciences. The program is intended primarily for those expecting to engage in the planning aspects, supervision, and management of solid waste disposal facilities. In addition to course work, the student will either participate in a research project, or in a comprehensive engineering project in the field of solid waste management.

EC-00006-04 (UI-01010-04)	GRADUATE TRAINING IN SOLID WASTES	PAUL W. PURDOM DREXEL INSTITUTE OF TECHNOLOGY PHILADELPHIA, PENNSYLVANIA

Objectives: This program provides Master's level graduate study dealing with the solution of solid wastes problems. The program is intended to produce graduates equipped to: (1) organize and administer solid wastes activities at the federal and state and local levels, (2) staff other organizations requiring specialists in solid wastes technology, and (3) conduct limited scale research and development studies in solid wastes technology. This curriculum includes consideration of: (1) the characteristics and quantities of solid wastes, (2) collection and disposal systems (3) theory and design of waste disposal processes, (4) pertinent planning and management techniques, and (5) the relationships between solid wastes and other environ-

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION

EC-00006-04 (Continued)

mental concerns, i.e. water and air pollution. In harmony with its urban setting, the program emphasizes those aspects of solid wastes disposal of paramount concern in a megalopolis.

EC-00007-03 (UI-01012-03)

SOLID WASTES

RUSSELL H. SUSAG
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

Objectives: This program is designed to provide training on the graduate level in the area of solid wastes collection and disposal. Personnel will be trained in the design and operation of collection and disposal systems and in research and development of basic design data.

Students specializing in solid wastes management will take specific courses amounting to approximately one-half the total hours required for a Masters degree. As the program develops a system analysis approach will be included.

An interdisciplinary committee will coordinate research and training in solid wastes. Currently this committee includes members from chemical engineering, environmental engineering, soils, and botany.

Publications: Gargiulo, Frank John. "A Study of Solid Waste Collection and Disposal Methods for Western Palm Beach County, Florida." A thesis. 195 pages. 1968. University of Florida.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00008-04 (UI-01013-04)	SOLID WASTES ENGINEERING	EUGENE A. GLYSSON UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN

Objectives: To provide for the trainee a broad interdisciplinarian program centered around the topic of Solid Wastes. This requires courses providing the background for the evaluation of methods used for collection and disposal of solid wastes as they affect the general environment including the air, water and land. Since the problems are not limited to small political areas or regions, it is essential to include the concepts of planning, both urban and regional, so that wider area solutions can be developed. Administrative practices, both personnel and fiscal, plus satistical and systems analysis are involved. This program will provide a background which will be conducive to the development of new methods and proper application of known methods to the solution of the diversified and difficult solid waste problems of the present and future.

EC-00009-03 (UI-01014-03)	SOLID WASTES	RAUL ZALTMAN WEST VIRGINIA UNIVERSITY MORGANTOWN, WEST VIRGINIA

Objectives: This program is designed to expand Master's level teaching which emphasizes solid wastes. This program encourages research in broad areas of the economic, and engineering aspects of municipal refuse handling, land reclamation, and related special problems.

Students specializing in solid wastes take specific core courses amounting to at least half the hours required for the master's degree. Qualified non-engineering

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION

EC-00009-03 (Continued)

graduates can enter the environmental engineering program on an open enrollment plan.

The solid waste training program is mutually supporting with graduate programs in air pollution control and water supply and waste treatment. This interrelationship provides the student with the opportunity to participate in an active, broad scope environmental engineering program.

The graduate education and research at the university has an interdisciplinary approach.

EC-00010-04 (UI-01015-04)

SOLID WASTE

JOSEPH F. MALINA, JR.
UNIVERSITY OF TEXAS
AUSTIN, TEXAS

Objectives: This is a multidisciplinary program with specific emphasis on the application of new engineering principles and processes to the solution of problems of solid wastes disposal.

The scope of this project includes the training of graduate students, the development of a competent health-related teaching and research training program and the opportunity for both faculty and students to study new approaches to the disposal of solid wastes resulting from municipal and industrial activities.

Publications: Malina, J. F., Jr. and Gazda, Lawrence P. "Land Disposal of Municipal Solid Wastes in Selected Standard Metropolitan Statistical Areas in Texas." Technical Report No. EHE-69-13. 114 p. April 1969. University of Texas.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00011-03 (UI-01016-03)	SOLID WASTES	ROSS E. McKINNEY UNIVERSITY OF KANSAS LAWRENCE, KANSAS

Objectives: The solid waste program is a dual program at two levels of graduate education. It is designed for both engineers and scientists at the M.S. and the Ph.D. levels. Research and special problems are used at both levels to develop new concepts and to apply these concepts to real problems in solid waste. Emphasis is placed on a broad base of environmental sciences followed by engineering applications. Secondary areas include business management and public administration.

EC-00012-02 (UI-01022-02)	SOLID WASTES TECHNOLOGY FOR URBAN AREAS	H. NUGENT MYRICK UNIVERSITY OF HOUSTON HOUSTON, TEXAS

Objectives: This program offers training (instructional and research) in environmental sciences and engineering with study emphasis on urban areas. Interdisciplinary courses which have been prepared are Solid Wastes Collection System Analysis, Solid Wastes Conversion Processes and Technology, and Solid Wastes Monitoring and Measurements. Research interests of the faculty include the development of standard tests for evaluating land fill, land reclamation, biodegradability, pyrolytic techniques and novel oxidative combustion techniques for waste conversion and the biochemical conversion processes of solid wastes.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00032-02 (UI-01066-02)	SOLID WASTES MANAGEMENT	RICHARD S. ENGELBRECHT UNIVERSITY OF ILLINOIS URBANA, ILLINOIS

Objectives: This training grant provides students with training in solid wastes management. The program is interdepartmental, involving faculty and students from the Departments of Civil Engineering (Sanitary Engineering), Food Science and Agricultural Engineering. This program of study is being offered initially at the M.S. degree level. Trainees are graduate students seeking a M.S. degree in one of the participating departments. Each trainee's academic program consists of the two new courses in solid wastes, the course requirements of the department in which the student is registered plus other courses necessary to his program. The students completing this program will be capable of working on problems of the management of municipal solid wastes, food processing solid wastes or agriculture (animal feeding) solid wastes.

EC-00033-04 (UI-01011-04)	SOLID WASTE TECHNOLOGY	FREDERICK G. POHLAND GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA

Objectives: This program provides specialized interdisciplinary graduate training in solid waste technology founded upon the basic and applied sciences associated with methods of solid waste management and control. Such training includes emphasis on pertinent unit operations and processes, systems analysis and optimization, economics and financing, and program administration. This emphasis is accommodated by a core curriculum in solid waste technology, by suggested graduate curricula in the contributing disciplines and by the use of seminars and special short-courses

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00033-04 (Continued)	and conferences available to program participants as well as local practitioners. In addition, special solid waste courses are available which provide opportunity for case study and application of course material to selected solid waste problems in the field.	
EC-00038-01 (UI-01084-01)	TRAINING IN SOLID WASTE DISPOSAL	NATHAN C. BURBANK, JR. UNIVERSITY OF HAWAII HONOLULU, HAWAII

Objectives: To introduce three major new courses for students of environmental sanitation into the curriculum of the Department of Environmental Health of the University of Hawaii's School of Public Health. The courses are designed to meet the need expressed in the report of the National Academy of Sciences--National Research Council on "Waste Management and Control" for adequate training programs in solid waste control in the Nation's colleges and universities. The courses are "Solid Waste Management and Control," "Analysis of Solid Waste," and "Design of Solid Waste Facilities." The courses provide comprehensive instruction in the technical, economic and geographic factors of importance to the design and management of solid waste systems.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00009-02	HIGH DENSITY LANDFILL RECOVERY PROGRAM	J. NICHOLSON KING COUNTY SANITARY OPERATIONS SEATTLE, WASHINGTON

Objectives: To construct and operate a machine which will compact refuse at 200 psi, extrude the compacted refuse substantially below ground level, and compact cover material placed over the in-place refuse by auxiliary earth-moving equipment.

To determine the suitability of land reclaimed by this method for use as a building construction site that will not settle or slump.

Progress: Bids for construction of the compacting machine (otherwise known as "the mole") were awarded on September 18, 1967. The machine was essentially completed and moved onto the demonstration site in mid-1968 and was successfully tested in July of that year. The county's transfer trailers have been modified to permit easy dumping of solid wastes into the compacting machine. The trailers have been converted from the conventional end-unloading type to a type having two 42-cu-yd containers on the truck bed. These containers are filled with solid wastes at the transfer station and, one at a time, a hydraulic unloader turns the container upside down and empties it into the hopper of the mole at the site. The unloading operation takes about 3 to 4 minutes for each container. A large hydraulic cylinder in the mole then compresses and extrudes the refuse into a trench previously excavated by auxiliary equipment.

Special earth tamping devices provided on the mole to compact the backfilled earth have been found to be unnecessary; a bulldozer adequately compacts the backfill. Other preliminary observations are: (1) Refuse is extruded from the mole as a 7- by 7-foot strip, which does not expand appreciably as it leaves the machine, and is deposited in the trench. (2) In-place density of the extruded material is estimated to be 1,500 to 2,000 pounds per cubic yard. (3) As a preliminary test, a one-day production of refuse from King County (800-900 tons) was compacted and buried by the equipment in about 8 hours in October 1968.

Rainy weather has hampered evaluation operations and delayed completion of the project. Data on density, land use, time of operations, and costs are being developed.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00010-02	WASTE INCINERATION MECHANICAL AGITATED FLUIDIZED BEDS	R. C. BAILIE BOARD OF GOVERNORS WEST VIRGINIA UNIVERSITY MORGANTOWN, WEST VIRGINIA

Objectives: To conduct a quantitative study of the extent to which the many potential advantages of the fluidized bed for cleaner and more economical disposal of a wide variety of solid wastes may be realized.

Progress: Generation pilot plants have been constructed. The following significant results have been obtained:

1. For burning 1 by 1 by 12 inch pine block and charcoal briquets:

   (a) Reaction is not chemical reaction controlled.

   (b) Ninety percent of briquets burn in 3 to 4 minutes at 1700°F.

   (c) Little increase in burning rate is observed above 1700°F.

   (d) Ignition temperature is about 700°F for pine blocks and 900°F for charcoal.

2. Tin cans are oxidized and give off their reaction energy in the bed. About ten minutes residence time is required.

3. Sand elutriation remained high.

4. Oxygen concentrations as low as 2 percent were obtained by inserting the heat removal coil in the bed.

5. In preliminary experiments, glass inserted in bed did not agglomerate.

6. The oxygen level had a significant effect on reaction rate.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00010-02 (Continued)

The major problem for small-scale investigations continues to be the feeder. No satisfactory solution has been found for a reliable feed system that allows for continuous steady-state operations employing a wide variety of heterogeneous feed.

The pulse technique developed and presently being modified has proved to be a most valuable technique for the study of combustion efficiency and the effects of particle size, moisture content, bed temperature, oxygen concentration, heating value, etc. This technique is far less time consuming than a steady-state operation and gives valuable information about the kinetics of the combustion that could not be obtained from steady-state operation. This technique is being used to exclude areas of operation that would be undesirable and to direct the time consuming steady-state operations toward the most significant areas for investigations.

The incineration of pine blocks and charcoal briquets in less than 5 minutes is a qualitative verification of high combustion rates. To take advantage of high combustion rates leading to small compact units, it will be necessary to remove heat even where there is no utilization of this energy.

The advantages in reducing gaseous emissions from incineration have not been substantiated. It would appear from other work, that the oxides of nitrogen may be more than predicted. On the other hand, pollutants such as sulfur dioxide, chlorine, etc., can be reduced substantially by adding material such as dolomite to the bed to tie up these trace constituents.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00030-03	GAINESVILLE MUNICIPAL COMPOST	H. W. HOUSTON MUNICIPAL WASTE CONVERSION AUTHORITY, INC. GAINESVILLE, FLORIDA

Objectives: To demonstrate the reliability, suitability, economic feasibility, and sanitary and nuisance-free operation of a recently developed high-rate, mechanical composting system for the disposal of municipal refuse from a medium-sized community.

Progress: Early in April, the plant began operating at full capacity and received refuse from the city of Gainesville and Alachua County. By April 12, some 150 tons per day were being received. In June, the University of Florida began delivering its refuse to the plant.

The technical evaluation of the process has been hindered by lack of established and proven sampling and analytical methods. Progress made to date is summarized as follows:

Carbon was diminished during the digestion of solid waste and the curing of compost. Although this reduction can be assumed, previously it was not conclusively demonstrated at the Gainesville Compost Plant. Nitrogen apparently increases during waste digestion. The C/N ratio of waste decreased with increasing treatment time and generally followed the BOD reduction. Preliminary results indicate that the BOD test is satisfactory for determining waste stability or degree of treatment; COD and volatile solids tests were not satisfactory for this purpose. A method was developed for sampling solid waste. Good sampling is necessary before meaningful data representing waste before and after treatment can be obtained. The method employs a fiberglas bag to contain the waste during treatment and to ensure its retrieval after treatment. Thus, virtually the same sample can be analyzed before and after treatment, and the results are much less erratic than random sampling procedures. A similar bag was used for the successful demonstration of coliform die-off during composting.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00030-03 (Continued)	A health hazard is suggested by the finding of viable particles in the atmosphere surrounding the plant in the size range that can penetrate the lungs. The uncertainties of clinical research will tend to preclude any correlation between this potential hazard and actual lung diseases in the plant workers. This suggests the use of laboratory animals that can be exposed to dusty atmospheres and then sacrificed for careful examination. Plans are being made to strengthen the medical and the insect and rodent control programs.	
EC-00039-02	MARICOPA COUNTY-WIDE SOLID WASTE DISPOSAL	J. J. WEINSTEIN MARICOPA COUNTY HEALTH DEPARTMENT PHOENIX, ARIZONA

Objectives: To demonstrate how new or improved solid waste management techniques could solve a regional solid waste problem by developing a solid waste disposal system and plan for county-wide reference and use, and by developing a protocol and timetable for putting the plan into effect.

Progress: There is no significant difference in fiscal year 69 over that in fiscal year 68.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00045-03	BUILDING AMPHITHEATER & COASTING RAMP WITH MUNICIPAL REFUSE	C. S. KILEY CITY OF VIRGINIA BEACH VIRGINIA BEACH, VIRGINIA

Objectives: To demonstrate the feasibility of constructing an above-grade sanitary landfill with municipal refuse to serve as an amphitheater and coasting ramp.

Progress: The hill which has been built up with compacted refuse and cover material to a height of 14 feet, 9 feet above the original ground surface and 4 feet below, will have a total height of some 60 feet.

Since April 1, 1967, all refuse from Virginia Beach (estimated population 150,000) has been placed in the hill. Work has proceeded on a 6 day per week schedule. Incoming refuse is weighed, and other information such as truck identification, type of refuse, weather, and temperature is also obtained. These data are recorded on porta punch computer cards for analysis. During the past year, an average of 268 tons of refuse has been received during each operating day. The monthly averages have varied from a high of 341 tons per day to a low of 183 tons per day.

A FWD Wagner compactor is used to spread and compact the refuse. A bulldozer is used for spreading cover material and as a backup for the compactor when it is being repaired. Cover material is excavated by a dragline and loaded into dump trucks by a front-end loader.

Personnel from Old Dominion College are monitoring the project. Five wells have been sunk adjacent to the hill, and chemical and biological tests are being run to determine the effects, if any, of leaching on ground water. Settling plates, gas probes, and thermocouples have been installed. Random sampling of refuse is carried out to determine the character of the material being deposited in the hill.

Delays in procurement of equipment, adverse weather, and equipment breakdowns have slowed progress. Completion of the hill to its planned full height and recreational development of the area will require several more years.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00046-03	DEVELOP CONSTRUCT USE CRITERIA FOR SANITARY LANDFILLS	J. A. LAMBIE COUNTY OF LOS ANGELES LOS ANGELES, CALIFORNIA

Objectives: (1) The development of methods to control gas movements from existing and new landfills, (2) the development of methods to control leachate discharging from existing and new landfills, and (3) the development of a "Code" for use in controlling construction of buildings on completed sanitary landfills.

Progress: A comprehensive study of gas movement from sanitary landfills was undertaken. Eight sanitary landfills were selected in the Los Angeles area and general soil and geologic information was obtained for these landfills. A total of 363 shallow gas probes (2 ft. deep) and 10 deep gas probes (8 ft. deep) were installed around these landfills. Two sets of samples were obtained and analyzed from these probes. The results of these samples were employed to plot contours of equal methane and carbon dioxide concentration around each landfill. Correlations were developed between the pattern and extent of gas movement and the nature of soil formations, the topography, and the effect of existing gas control devices.

Laboratory experiments were conducted to test the suitability of natural soils for gas barrier membranes. Five soils with different particle size distributions were tested in laboratory diffusion columns at three levels of moisture content and three inflow gas pressure conditions. With the use of an analytical solution for the differential equation governing the flow of gases through porous media, diffusion-dispersion coefficients for each soil were determined. These data provided a basis for calculating the rate of flow of gases through these soils under different conditions of soil moisture and gas pressure. This, in turn, provides a basis for determining the relative degree of effectiveness of these soils as gas barrier membranes.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00046-03 (Continued)

Field experiments on gas barrier and control devices were also undertaken. These experiments encompassed the implementation of gas control systems at two of the sites in the Los Angeles area. One of these systems consists of perforated pipes installed directly on the sloping walls of an unfinished landfill. The deep well system will operate on the basis of combined gas suction and air flushing.

In addition, survey monuments were established at four selected sites and background data were collated on land subsidence in sanitary landfills. Information on the existing practices in sanitary landfilling and on various land uses on completed landfills was also collected. These data will form the initial input for the second-year program which will encompass the study of subsidence and the development of use criteria for completed landfills.

EC-00048-03

ABONDONED STRIP MINES FOR SOLID WASTE DISPOSAL IN MARYLAND

WINFRED H. SHIELDS
MARYLAND STATE DEPARTMENT OF HEALTH
BALTIMORE, MARYLAND

Objectives: To demonstrate the feasibility of using abandoned strip mines for sanitary landfills.

Progress: A sanitary landfill has been established and is operating successfully. The Frostburg site has expanded its operation by including the City of Cumberland. Roadside dumping has almost been eliminated as a result of the sanitary landfill. One portion of the Frostburg strip mine site is almost completely filled to grade. The remaining portion of the strip is still in the process of being filled.

The Westernport sanitary landfill is an accomplishment in itself. This site not only accepts refuse from Maryland, but also the State of West Virginia. This site has demonstrated it is possible to cross political boundries when establishing a collection area for a sanitary landfill. The experimental cells at this site have given an indication that refuse beds may be a way to reduce the acidity of acid mine water.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00050-03	EVALUATION OF ALTERNATIVES IN REFUSE DISPOSAL	W. J. MANN CITY OF RALEIGH RALEIGH, NORTH CAROLINA

Objectives: (1) To apply an existing mathematical simulation model to the City's refuse collection system to improve its efficiency. (2) To apply a mathematical model to evaluate alternative landfill sites. (3) To develop methods to maximize salvage benefits by choice of disposal method.

Progress: A simulation model for the collection system was adapted to the Raleigh loadpacker system. The object was to determine points of attack in improving collection. The model could be varied in a number of essentials to predict effects of changing the load carried per vehicle trip to the landfill, the number of collections per week, the number of pickup men, and the use of curb collection.

Among the findings of these studies were: (1) Loads carried per trip to the landfill were light compared to loads quoted by equipment manufacturers. Even small increases from 340 pounds per cubic yard to 500 pounds per cubic yard should effect savings by reducing the number of trips to the landfill. (2) Two collections per week would be as effective as three collections a week. One collection per week would result in substantial savings. (3) Curb collections would require only half as much labor as the present backyard collections. (4) Landfills close to the city offer obvious savings in haul costs. It is intended that each of these conclusions be tested in demonstrations on some routes in the city during 1969.

Landfill proved to be the least costly method of refuse disposal for the next ten years, even in the event that Raleigh had to purchase land. A number of potential landfill sites were examined, and a land acquisition program was recommended. Since there is a large amount of state-owned land in the Raleigh area, it is possible that in some cases at least the trade off of free collection service for the use of land is feasible.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00050-03 (Continued)		

Other studies included:

1. Welfare salvage that serves a useful, but somewhat limited, function in Raleigh. The amount of salvage in the categories of garments, furniture, paper, and scrap iron totals about 14 tons per week.

2. Wood scrap is used as fuel.

3. Rags are a possible source of salvage only if some other item is recovered; that is, it could not pay the cost of recovery on its own.

4. Metal scrap is almost completely salvaged.

5. Metal from tin cans is not a promising venture since the current markets are far removed from Raleigh.

6. Glass recovery does not appear practical because of problems of quality control and the very low cost of raw materials in the glass industry.

7. Rubber recovery is not feasible because of remoteness of markets.

8. Plastics are not at present an economically reclaimable material. Some of the urea form plastics find their way into the fertilizer.

9. Paper is a feasible item for recovery, but would require a large capital investment for separation. For most advantageous resale, a pulping and deinking operation should be included in any plan. The study does not recommend consideration of recovery at the present time. Few cities are equipped with the staff for promotion and sale of a product.

10. Composting of refuse with sewage sludge could be accomplished if a market could be developed. In that event, the combined recovery of paper and composting of refuse and sludge could be an economical means for disposal of two community waste products.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00050-03 (Continued)

11. Incineration is a relatively expensive means of refuse disposal. The heat value of Raleigh refuse is equivalent to about 60 tons of coal per day. The capital costs and operating expenses, however, place the disposal of refuse by simple incineration at about $4.70 per ton in Raleigh, or about 10 times the cost of landfill.

EC-00057-03 REFUSE CRUSHER - TACOMA, WASHINGTON

GILBERT M. SCHUSTER
DEPARTMENT OF PUBLIC WORKS
CITY OF TACOMA
TACOMA, WASHINGTON

Objectives: To demonstrate how demolition wastes can be efficiently incorporated into a sanitary landfill by prior treatment through a refuse crusher.

Progress: The study has been completed. Principal conclusions and recommendations are summarized below:

The present population of Broome County (222,000) produces an estimated 183,000 tons of refuse per year. Projected population by the year 2000 is 354,000 people with a refuse production of 446,000 tons per year. Broome County is an L shaped area, with the major part of its population concentrated at the junction of the two legs, in the city of Binghamton and environs. Of the total amount of refuse produced in the county, 85 percent is generated in the Binghamton area.

The recommended solid waste disposal system consists of three landfills; the largest to be established in the Binghamton area, with smaller landfills near the end of each of the legs of the county. The county should construct and operate these landfills with funds provided by a tax levied for this purpose. The Broome County Health Department should be the regulatory agency in charge of the refuse disposal system. Refuse collection should remain the responsibility of the individual municipalities.

The county has conducted a public information program to acquaint the public with the recommended disposal plan and the need for, and benefits of, a countywide system.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & OBJECTIVES	PROJECT DIRECTOR & LOCATION
EC-00073-01	BENEFIT RAIL HAUL AS INTEGRAL PART WASTE DISPOSAL	K. WOLF AMERICAN PUBLIC WORKS ASSOCIATION CHICAGO, ILLINOIS

Objectives: To make a comprehensive evaluation of the costs and benefits obtainable for the collection, transportation and disposal of solid wastes from urban areas by the use of railhaul techniques.

Progress: The most promising general approach to date involves various combinations of (1) transfer stations in the generating communities, (2) rail transport to remote sites, and (3) disposal by a modified sanitary landfill in carefully prepared sites.

Several basic transfer station designs have been generated and are now being refined to accommodate all the necessary techno-economic as well as environmental health aspects. The transfer stations are developed with capacities ranging from 50 to 1,000 tons per 8-hour shift to meet the differing needs of the many dissimilar communities across the country.

Findings to date suggest that rail transport could be feasible over distances as short as 10 miles to as much as 400 miles. Rail car design is also given some attention in consideration of longer-term system developments.

In the overall, the work to date suggests that waste-rail-haul holds considerable promise of alleviating urban solid waste disposal problems in the near future. There is a very strong likelihood that large savings in the local collection process of participating communities might result as a byproduct.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00080-03	PRACTICALITY-DISPOSING DIGESTED SEWAGE SOLIDS ON LANDS	C. T. NICKLE THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO CHICAGO, ILLINOIS

Objectives: To determine the agricultural benefits and environmental changes resulting from the use of digested sewage sludge on field crops, and to develop the economic and physical characteristic criteria for use in selecting disposal sites.

Progress: Conclusions from various studies conducted in 1968-69 are as follows:

It appears that if digested sludge is applied on crop land in quantities just sufficient to insure ample nitrogen and phosphorus for high crop yields, few if any problems will be encountered. Odors, flies or other insects were never a problem even when sludge was applied at rates exceeding the infiltration capacity of soils.

There is some indication that where heavy applications of sludge are applied on land to the extent that organic material accumulates with time, nitrogen volatilization may increase.

With continuous heavy applications of digested sludge some heavy metals, particularly copper and zinc, may accumulate in exceedingly high concentrations in soils. These may or may not present a problem to crop production.

The data available from pathogenic indicator studies now in progress are not yet sufficient to make an assessment with regard to the pollution of runoff and drainage water from land areas treated with digested sludge. But findings have been sufficient to indicate possible management practices for eliminating pathogenic pollution, many of which will be the subject of future studies.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00087-02	TOCKS ISLAND INTERSTATE SOLID WASTE MANAGEMENT STUDY	FRANK W. DRESSLER TOCKS ISLAND REGIONAL ADVISORY COUNCIL STROUDSBURG, PENNSYLVANIA

Objectives: (1) To demonstrate regional interagency solid waste planning under the leadership of a new type of regional agency consisting of representatives from the six member counties in the tri-state region affected by the Delaware Water Gap National Recreation Area. (2) To develop needed information and plans for optimum solid waste management facilities for the interstate region influenced by the Delaware Water Gap National Recreation Area. (3) To explore and demonstrate the feasibility of resolving a solid waste disposal problem on a regional basis through interlocal and interstate cooperation and action.

Progress: A report setting forth a detailed study design was completed in May 1968. This identifies the tasks to be undertaken in the study, the activities to be performed toward the completion of each task, the approximate sequence in which these activities are to be performed, and the proposed roles of the various participants in carrying out the activities.

Several solid waste management plans are being developed from which the most effective plan for the study area will be determined. The technical and administrative characteristics of the alternative plans are being reviewed and analyzed at joint meetings of the Steering and Technical Advisory Committees. Projections of population and waste generation have been completed. Waste sources and collection methods and systems have been identified.

A legislative study has been completed that identifies existing legal constraints on the regional approach to solution of the solid waste problem and specifies new governmental and intergovernmental arrangements that may be required for a regional management approach.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00087-02 (Continued)	A mathematical model is being developed that will provide a method for estimating costs of alternative solid waste management systems. The model will be finalized in two sections, the first of which will provide a description and technical justification of the model and procedures, whereas the second section will consist of work sheets and forms to be used when employing the model.	
EC-00091-03	BULK REFUSE CRUSHER FACILITY	L. S. WAGNAN CITY OF BUFFALO BUFFALO, NEW YORK

Objectives: To demonstrate the feasibility of reducing the size of bulky burnable solid wastes by a heavy duty impact crusher to permit disposal by incineration, which would not otherwise be possible because of the limited size of incinerator charging openings.

Progress: Construction contracts were awarded by the city in August 1967, and construction of the facility is complete except for the electrical controls. This work was expected to have been finished by March 1969, leaving 9 months for operation and evaluation of the installation.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00093-02	DEMONSTRATION OF SOLID WASTE DISPOSAL MACHINE	W. M. FRIEDMAN, JR. NIAGARA COUNTY SOLID WASTE AGENCY LOCKPORT, NEW YORK

Objectives: (1) To demonstrate the feasibility and advantages of consolidating and centralizing numerous local, public, private, and industrial solid waste disposal operations into a county-wide program to be carried out by the Niagara County Solid Waste Agency. (2) To demonstrate the feasibility of operating a sanitary landfill utilizing a newly-developed machine which combines in one unit the operations of trench excavation, refuse compaction and placement in the trench, and provision of a compacted earth cover over the compacted refuse immediately after placement.

Progress: Enabling legislation authorizing formation of the Niagara County Solid Waste Disposal District is currently in the State Legislature. Approval in the immediate future is anticipated. During 1968, the D&J Refuse Machine has been used only in limited landfill operations. Purchases of land and equipment and full-scale operation of the machine have been delayed pending formation of the disposal district.

EC-00102-02	DAIRY MANURE MANAGEMENT METHODS	D. E. PROCTOR WASHINGTON STATE UNIVERSITY PULLMAN, WASHINGTON

Objectives: (1) To demonstrate the advantages of properly scheduled applications of dairy manure to farm lands in areas having seasonally high rainfall and land runoff problems (2) to demonstrate the use of properly constructed and operated anaerobic lagoons as a feasible method of low-cost storage of dairy manure during seasons unfavorable for land disposal (3) to compare the relative economic and aesthetic advantages of a water transport system versus a dry system for the collection and disposal of manure (4) to demonstrate improvements attainable in manure management by providing total roof coverage of confinement areas and (5) to evaluate the feasibility of using lagoon treatment for dairies without sufficient land for solids disposal.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00102-02 (Continued)

Progress: The general requirements for facilities needed to accomplish project objectives were carefully reviewed. Four major areas of facilities design were established: (1) the cattle housing facility with provision for manure cleaning or collection (2) the manure transport, sampling, storage, and treatment facilities (3) the manure-slurry field-distribution system, and (4) the laboratory-office building. Substantial progress has been made in the construction of these facilities, although some delays have been encountered because of extremely wet weather, flooding, and slow delivery of equipment.

Plans were developed for obtaining background information on the milk production, milk quality, and health level of the cows housed in the existing confinement facilities. Several different series of tests have been completed. Tests are underway to evaluate the effect of improved sanitation and reduced environmental stress upon mastitis and production data. As more pens are completed, further tests will be undertaken to evaluate the effectiveness of different cleaning techniques.

Some experimental work has been done to develop hydraulic methods for cleaning or removing manure from the specially designed cattle pens. This work appears most promising both in terms of effectiveness and economy. Currently, it is believed that a very high-pressure, mobile spray boom will be capable of removing all manure from one of the large pens in a matter of 2 to 5 minutes. Hydraulic cleaning will provide a much cleaner living environment for cows, eliminate the rapid erosion of the floor slabs that occurs with blade-type manure scrapers, and accomplish cleaning at greatly reduced costs when compared with conventional methods.

A 10-acre section of the farm has been sub-divided into over 200 test plots. These plots are being operated to evaluate the agronomic or fertilizer significance of various manure applications to various crops.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00102-02 (Continued)

Operational studies on the storage and treatment of manure have been delayed because the necessary facilities are not yet complete. Plans for study of costs and effectiveness of the facilities will be initiated as rapidly as possible when the facilities are completed.

EC-00106-02

DEMONSTRATION OF IMPROVED INCINERATOR TECHNIQUES FOR SMALL COMMUNITIES

W. K. SMITH
SHIPPENSBURG SANITARY AUTHORITY
SHIPPENSBURG, PENNSYLVANIA

Objectives: To demonstrate that a small mechanically stoked rotary grate incinerator can provide a small municipal area with a feasible means for the disposal of solid wastes, which will meet air pollution standards, eliminate environmental health hazards, and be the most economical method of disposal in an area where sanitary landfill methods cannot be adopted.

Progress: Construction of the incinerator was completed and shakedown operation begun in November 1968. The facility will be dedicated in January 1969 and then placed in full operation.

EC-00111-01

AMBOS NOGALES INTERNATIONAL SOLID WASTE DISPOSAL PROJECT

WALTER WETTEN
CITY OF NOGALES
NOGALES, ARIZONA

Objectives: The purpose of this demonstration project is to show thattwo sister cities of different countries sharing the common problem of solid waste disposal can cooperate with each other to attain the most feasible solution. In the case of Ambos Nogales, this solution consists of a single jointly operated sanitary landfill that will dispose of all solid waste from both communities in an approved sanitary manner. The Ambos Nogales area has been suggested for this demonstration due to its

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00111-01 (Continued)

central location on the western half of the border, the extreme need for a mutually operated solid waste disposal program, and the availability of land and facilities with which to operate the solid waste sanitary landfill.

Progress: This is a new project, therefore significant progress is not available.

EC-00113-02

UTILIZATION SAN LANDFILL THROUGH INTEGRATED REGION PLAN

A. S. KOCH
COUNTY OF ORANGE
SANTA ANA, CALIFORNIA

Objectives: (1) To develop a long-term, regional solid waste disposal program involving novel concepts for the reuse of sanitary landfill sites to obtain the maximum efficiency of use and reuse of publicly owned lands and minimize overall costs of sanitary landfill operations. (2) To develop a prototype interagency planning program to integrate all governmental planning functions (highways, schools, flood control, water quality control, air pollution control, parks, recreation, refuse disposal, etc. which will provide useful procedures and policies that will aid in securing the public's acceptance of regional solid waste management programs. (3) To develop a "model" ordinance which will provide the means for implementing the regional solid waste disposal program developed from the interagency planning program noted in (1) and (2) above.

Progress: The principal work effort has been the development and compilation of basic data relative to a thorough understanding and analysis of the County of Orange's disposal program and refuse collection practices, the present and estimated futute generation of solid wastes in the study area, the status of existing land use planning and potential future land use, present and projected population analyses, and a review of the disposal programs and practices of adjacent counties.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00115-01	DEMONSTRATION OF DISPOSAL WASTE WOOD-BULK BURNABLE OBJECTS BY LARGE CITIES	G. W. SUTTERFIELD CITY OF ST. LOUIS ST. LOUIS, MISSOURI

Objectives: To demonstrate the feasibility of a major city (1) salvaging wood wastes by preparing them for use as pulp wood and (2) effecting size reduction of bulky burnable wastes for incineration at a site not adjacent to the incinerator.

Progress: The engineering firm of Horner & Shifrin, Inc., St. Louis, Missouri, has been retained to provide consulting engineering services for the project.

Various items of equipment have been purchased, including a hammermill, electrical equipment, and conveyors to move the wastes to and from the mill. Delivery of the hammermill and associated equipment is scheduled for March 1969. Specifications have been prepared for installation of the equipment, when received.

The project has been delayed so that it is now approximately 6 months behind schedule. The grantee is expected to request a corresponding time extension for the life of the project.

EC-00133-02	SANITARY LANDFILL & RECLAMATION PROJECT	E. E. LILLARD CITY OF BIG SPRING BIG SPRING, TEXAS

Objectives: To demonstrate that an improved method of solid waste disposal (sanitary landfill) can reclaim eroded land for agricultural purposes, prevent further erosion damage to an interstate highway and productive land, and successfully implement an effective soil erosion control program.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00133-02 (Continued)

Progress: Site preparation and landfill operations are progressing as planned. A fence with a gate has been installed so regular opening and closing hours can be observed. A drainage way has been cleared and planted with grass to prevent erosion when the site is placed in service. Also, a gravel access road has been completed. A set of truck scales with a 50,000-pound capacity has been installed, and a scale house has been built. Each vehicle bringing wastes to the site is weighed and records are maintained of the weight of wastes being placed.

The present gully site is nearing completion, and operations are scheduled to move downhill approximately February 1, 1969. Cross sections were taken before the project started, and periodic sections are being taken as the sanitary landfill operation continues. During the first 6 months of operation, a total of 7,029 tons of solid wastes were placed in the landfill.

EC-00135-02 STUDY CONTAINER-TRAIN METHOD OF SOLID WASTE COLLECTION AND DISPOSAL

J. J. ROARK
CITY OF WICHITA FALLS
WICHITA FALLS, TEXAS

Objectives: To determine how solid waste disposal services of a city could be improved by developing a comprehensive management model of a solid waste collection and disposal system utilizing the container-train system of collection.

Progress: One of the initial steps was a thorough definition and review of the major activities proposed for the project. This work was summarized on a PERT chart that shows proposed activities for the 3-year project period which lists and describes these activities.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00135-02 (Continued)

A data collection system was designed to provide the necessary information to attain the project objectives. Work has begun on a system evaluation by processing certain types of data. Procedures have been developed that will permit cost accounting for all aspects of the solid waste collection system.

Procedures and data collection techniques have been developed that will provide daily information on the solid waste collection operations. Data on personnel, equipment, cost, and weights for the packer truck operation have been collected on a daily basis since October 1968. Procedures have been established for describing the local network of streets and alleys in a manner permitting computer utilization of the network data so that studies of equipment routing may be conducted.

The city designed a device to transmit information from the packer truck to an IBM 1300 computer. Delays have been encountered in securing authorization from the FCC for an additional local government radio station for such transmission. This has delayed progress on other elements of the project.

EC-00143-01

DEMONSTRATION CONVERSION OPEN BURNING DUMP TO RECREATION AREA

R. R. PERRY
DEPARTMENT OF SANITARY ENGINEERING
GOVERNMENT OF THE DISTRICT OF COLUMBIA
WASHINGTON, D.C.

Objectives: To demonstrate how open dumping and burning of trash can be eliminated and the site of the burning and other small tracts of land, within densely populated metropolitan areas, can be reclaimed for recreational use utilizing model sanitary landfill methods.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00143-01 (Continued)

Progress: On April 2, 1968, landfill operations began. A complete rat abatement program, covering the entire site, was carried out by a professional exterminator. Piles of burned or partially burned material were compacted and covered with 6 to 8 inches of earth.

The contractor has used the area method of filling during his entire sanitary landfill operations thus far. Refuse is dumped from the incoming trucks at the bottom of the sloping face and compacted with the compactor dozers as they push the material up the slope. Earlier test pits proved misleading, and a considerable fill volume was made available for refuse disposal when earth from previously filled areas and some virgin areas were excavated to the limit. The limit of excavation was either burned residue or ground water. Where ground water was encountered, a layer of several feet of earth was placed and compacted before placement of any refuse. This additional fill volume has allowed the landfill operation to continue.

The project to demonstrate the sanitary landfill as a satisfactory method of disposal would seem to have already had positive results for the District of Columbia. The National Park Service, which entered the original Kenilworth agreement as a skeptic, now appears satisfied that such an operation can be carried out in proper locations to benefit both the Park Service and the District.

EC-00145-01 CURRICULA & TECHNIQUES IN SOLID WASTE MANAGEMENT

CARL SCHWING
CHARLES COUNTY COMMUNITY COLLEGE
LA PLATA, MARYLAND

Objectives: To demonstrate a method for training technicians in solid waste management.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00145-01 (Continued)

Progress: The one-year curriculum in solid waste management has been prepared. First semester courses will be Introduction to Solid Waste Management and Control, English, Applied Mathematics, Applied Biology, and Solid Waste - Collection and Storage. Second semester subjects are Basic Engineering Concepts, Community Problems and Public Relations, Systems Concept in Solid Waste Management, Solid Waste Disposal, Equipment Operation and Utilization, and Technical Report Writing.

Each semester will involve 16 credit hours allotted to the course work shown. Detailed teaching plans for each course are being completed. Arrangements have been made with the Department of Public Works of Prince Georges County, Maryland, to hold some of the training sessions at their model sanitary landfill.

A short course in solid waste management, designed to give an overall picture of the problems involved and some of the solutions available, was given on March 24 to 28, 1969.

EC-00153-01 DEMONSTRATION OF COMPACT INCINERATION SYSTEM

A. G. ILG
TOWN OF WINDSOR
WINDSOR, CONNECTICUT

Objectives: To evaluate a small incineration device that offers an improved means of solid waste disposal for small communities.

Progress: Final arrangements are being made for conducting the evaluation tests which are scheduled for January 1969.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00159-02	REGION SOLID WASTE STUDY-DESIGN & IMPLEMENTATION PROGRAM	R. BONITATIBUS CENTRAL SAVANNAH RIVER AREA PLANNING AND DEVELOPMENT COMMISSION AUGUSTA, GEORGIA

Objectives: To demonstrate that an area commission, by developing and implementing a regional plan for solid waste disposal, can effectively deal with problems of solid waste collection and disposal in the 13-county area served by the commission.

Progress: There are some 55 communities in the study area; fourteen of these communities provide at least twice weekly refuse collection. None of the communities have records regarding waste generation. To have a basis of estimating per capita generation, weighing programs have been instituted in several small representative communities. A report has been submitted to the city and county officials outlining the need for and the use of weighing records.

A model refuse ordinance for use in the study area was written. This covers most of the considerations related to solid waste storage, collection, disposal, and enforcement and will be used as a guide to improve existing ordinances or to establish new ordinances. A form was also prepared for community use in recording their refuse collection and disposal expenses. At present many of the communities are unaware of the actual cost of their refuse programs.

The refuse collection programs for the cities of Augusta and Sylvania were evaluated, and suggestions for improving the operation were made. A similar evaluation, with recommendations, was made for the landfill operation being conducted by Sylvania. A course outline was prepared for the sanitary landfill school to be held in Sylvania in the spring of 1969.

Preliminary consideration of a comprehensive solid waste collection and disposal plan for the study area indicates that the most economical solution would appear to be the establishment of a number of landfills, each of which would serve several communities without requiring excessive hauls Sites would be operated on a 5-day

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00159-02 (Continued)

per week basis, and all expenses would be borne by communities and counties using the site. With the exception of the Richmond County site, the total community population served would range from 5,000 to 15,000.

For communities not having existing collection services and for the rural population, the use of strategically placed bulk-storage containers is proposed, with a collection route designed to provide adequate coverage and pickup of wastes.

A system of this type, operated with the cooperation of residents of the area, is believed to result in controlled sanitary disposal of much of the solid waste of the area.

EC-00164-02

SOLID WASTE HANDLING & DISPOSAL IN MULTI-STORY BUILDINGS AND HOSPITALS

J. A. LAMBIE
COUNTY OF LOS ANGELES
LOS ANGELES, CALIFORNIA

Objectives: To demonstrate the need for improved equipment, methods, and practices in refuse collection and disposal at various county buildings and institutions by making an in-depth study and to provide design standards and code requirements that will ensure adequate sanitary facilities in all buildings to be constructed within the county jurisdiction.

Progress: Preliminary observations of refuse disposal practices are virtually complete. Weights of refuse from all but one facility have been obtained and tabulated. Planning and scheduling of in-building studies at hospitals are near completion. Results to date confirm that many facilities do not handle refuse efficiently and that crowded and unsanitary conditions exist in trash areas in many buildings.

Numerous articles and brochures concerning refuse handling equipment have been received and are being reviewed. In connection with investigation of various refuse disposal practices, inspections of four hospitals in Florida have been completed.

The project is proceeding essentially on schedule.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATIONS
EC-00170-01	DEV/TEST COMPACTION/BALING EQUIPMENT FOR RAIL-HAUL OF SOLID WASTE	J. V. FITZPATRICK CITY OF CHICAGO DEPARTMENT OF STREETS & SANITATION CHICAGO, ILLINOIS

Objectives: To demonstrate the development and application of improved equipment for solid waste disposal by conducting a study: (1) To determine the requirements for the optimum design of production-scale equipment to compress solid wastes into high-density economical payloads for transport by rail, and to test the operational aspects of such a system. (2) To investigate the potential for utilization of compacted solid wastes as a fill material in lake-shore areas. (3) To explore the potential of multi-compaction transfer stations as a means of reducing solid waste collection costs through shorter haul distances. (4) To investigate whether or not the compacted refuse can be placed in a sanitary landfill without causing degradation problems and associated methane gas production.

Progress: The press has been obtained, modified and installed for the testing program. The other materials and facilities needed have been brought to the site of the Solid Wastes Research Facility, and all is in readiness for the actual tests to begin. The test program is scheduled for January, February, and March 1969. No specific data are yet available.

EC-00178-02	CLEAN AND GREEN-CHILTON COUNTY ALABAMA	R. M. ALEXANDER BOARD OF REVENUE & CONTROL OF CHILTON COUNTY CLANTON, ALABAMA

Objectives: To demonstrate how improved management techniques can solve the solid waste problems of a predominately rural country by providing county-wide collection of municipal and rural solid wastes for disposal at a single, centrally located sanitary landfill.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00178-02 (Continued)

Progress: During the first 3 months of the project, the landfill site was surveyed and prepared. Specifications for the day-to-day operation of the landfill were developed. Equipment was ordered and delivered including a D-7 catapillar tractor for the landfill, and a 30-cubic yard packer truck and 60 four-cubic yard containers for the rural collection system.

The landfill operations began in September 1968; however, installation of scales was not completed until December 1968. Shortly after the landfill opened, the municipalities closed their open burning dumps, instituted rat eradication programs at these sites, and began covering them with clean dirt.

The rural collection system was started in January 1969 on county roads and approval is being sought from the State Highway Department and the Bureau of Public Roads for placement of containers on other public roads.

EC-00185-01 TWO APPROACHES-WOOD REMOVAL FROM BOXCARS FOR SALVAGE OPERATIONS

D. L. BUTLER
RAILROAD CAR DISMANTLERS
CHICAGO, ILLINOIS

Objectives: The objectives are to generate information suitable to appraise the economic and engineering feasibility and the public health, safety, and efficacy aspects of:

1. Hooded incinerator -- portable or fixed.

2. Water-jet removal of wood from railroad cars for the purpose of preparing retired railroad cars for further dismantling in scrap and salvage operations. These methods require examination of their practicality for use in scrap yard operations where air pollution contributions must be reduced or eliminated at costs which are consistent with recovery of material resources found in no longer useful cars.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00185-01

Progress: The principal activities and accomplishments during this reporting period have been: Completion of preliminary facility layout and site preparation specifications, advertisement in Commerce Business Daily for subcontractor assistance for the semi-enclosed incinerator, selection of a site preparation contractor, initiation of track construction at demonstration project site, establishment of office facilities at demonstration project site, and receipt of bids for water-jet and incinerator equipment.

EC-00188-01 TEST FEASIBILITY OF REFUSE BALING MUNICIPAL REFUSE

ERIC QUARTLY
CITY OF SAN DIEGO
SAN DIEGO, CALIFORNIA

Objectives: This project is to make a study and investigate and evaluate the feasibility of refuse baling as a means of conserving sanitary landfill space. The proposed two-year project is to construct and operate a pilot baling transfer station in order to test the technical and economic feasibility of baling municipal refuse. Other objectives include the development and evaluation (1) of data on the economics and techniques of the pilot operation and (2) of techniques for the efficient and effective disposal of refuse bales.

Progress: This is a new project, therefore significant progress is not available.

EC-00190-01 SOLID WASTE DISPOSAL BY UNDERGROUND INCINERATION

RALPH STONE
CITY OF SANTA CLARA
SANTA CLARA, CALIFORNIA

Objectives: To investigate controlled incineration of refuse as a satisfactory, nuisance free and economical method of solid waste treatment; to evaluate the unit costs of underground incineration under pilot-scale field conditions and project the

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00190-01 (Continued)

costs for a full-scale operation; to evaluate the potential effect of underground incineration on existing sanitary landfill life; to determine the nature and efficiency of the filtration capacity of surrounding soil types and conditions; to develop comprehensive cost information on underground incinceration and to determine the relative effect of constituent cost factors such as land value, haul distance, air pollution regulations, refuse composition, residue disposal, and construction costs on overall economics associated with underground incineration; to evaluate the relative merit of the method in comparison with other potential disposal methods available for the City of Santa Clara and other large metropolitan areas; to evaluate ground water, gases, air pollution, and other public health-environmental effects; and to evaluate oxidized residue, landfill stability for foundations of structures, ultimate use of the completed landfill, etc.

Progress: This is a new project, therefore significant progress is not available.

EC-00194-01

TOTAL REFUSE DISPOSAL BY FLUID MECHANICAL SEPARATION

B. F. EICHOLZ
CITY OF FRANKLIN
FRANKLIN, OHIO

Objectives: The proposed program includes engineering, construction, operation and evaluation of a solid waste disposal system which incorporates new and improved processes. The constituents in refuse will be separated into compacted noncombustible solids and combustible solids by a fluid-mechanical process. The combustible solids, separated in a slurry form, will be prepared for burning in a fluidized bed oxidation unit. The process has a unique capability for improved economical disposal of raw sanitary sewage sludge by incorporating it in the process. It is expected that the full-scale plant operation will substantiate findings in preliminary pilot plant operation and studies that:

1. Municipal refuse can be processed to reduce curbside volume by as much as 95 percent.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00194-01 (Continued)

2. Improvement in sanitary conditions will be obtained as compared to present landfill methods.

3. Improved sewage sludge disposal can be obtained at reduced cost.

4. The process will be economically feasible.

5. The opportunity to recover usable products will be improved.

Progress: This is a new project, therefore significant progress is not available.

EC-00195-01

USE OF SOLID WASTE AS A FUEL FOR GENERATING STEAM BY LOCAL GOVERNMENT

WILLIAM E. GEORGE
(STANLEY ENDLICH)
CITY OF LYNN
LYNN, MASSACHUSETTS

Objectives: To determine the feasibility of a joint private-public venture in which the General Electric Company will burn municipal refuse from Lynn as low-grade fuel to fire a steam-generating boiler constructed with private funds in the River Works Industrial Complex, Lynn, Massachusetts.

To demonstrate that municipal refuse costs can be reduced by utilizing existing private resources in the processing of solid waste.

To show that the joint venture concept of processing of refuse and steam generation can be applied as a satisfactory solution to the waste disposal problem not only locally in the Boston Metropolitan Region, but in other parts of the nation as well.

Progress: This is a new project, therefore significant progress is not available.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00197-01	EQUIP INCINERATOR WITH AIR POLLUTION CONTROL SYSTEM	V. H. BAUM CITY OF RYE RYE, NEW YORK

Objectives: To demonstrate the feasibility of disposing of bulky municipal refuse discards such as upholstered sofas, chairs, other furniture, carpets, mattresses, box springs, television cabinets, juke boxes, combustible demolition waste, tree trunks, leaves, automobile tires and the like in a specially designed incinerator equipped with an advanced air pollution control system. At the same time to demonstrate the feasibility of equipping the existing incinerator furnaces in the plant with similar air pollution control systems. The existing incinerator is unable to process this bulk waste due to size of the charging openings, grate design and discharge gates. This bulk waste is now being burned in the open and adding to the air pollution created by the existing plant.

Detailed construction plans have been developed in 7 drawings, and were submitted with the application. Also submitted were 2 schematic flow diagrams. The 7 drawings show all details of the installation, and since these drawings are at this advanced stage, a prompt construction start is possible.

Progress: This is a new project, therefore significant progress is not available.

EC-00202-01	CONTAINERIZATION OF FAMILY REFUSE	M. G. STRAGIER CITY OF SCOTTSDALE SCOTTSDALE, ARIZONA

Objectives: The objective of this project is to develop a standard container for family household and yard refuse. Once such a container has been standardized, its collection can be mechanized and the high costs of present collection can be reduced. Work is progressing on the development of a container which two families can use for

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00202-01 (Continued)

twice-per-week service, or one family can use for one-per-week service. If it is found practical, several families will be served with each container.

This proposal has been discussed with two equipment manufacturers who have indicated their interest in mechanization once frequency of service and size of container have been standardized. In cooperation with the manufacturers, efforts will be made to develop a mechanized system which can be placed anywhere.

Progress: This is a new project, therefore significant progress is not available.

EC-00208-01 PIPELINE TRANSPORTATION OF SOLID WASTES

L. P. BERRIMAN
STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA

Objectives: This study and investigation is a first step toward the construction of technically and economically feasible facilities for high-volume transportation of various types of solid waste by (1) long-distance pipelines from central stations to remote landfill, or other disposal locations, and (2) intermediate-length pipelines that traverse, or terminate in, areas where truck congestion is undesirable. The overall objective is to develop the preliminary design of a small-scale pilot plant for experimental verification of the design and operating features of full-scale solid waste pipeline facilities. The pilot plant will provide for comprehensive experimental work with that system or systems of pipeline transport having the greatest potential benefit as determined by the analysis and experimentation proposed herein. Full consideration will be given to possible adaptations of current solids pipelining practices; the analysis will also take into account recent investigative and experimental work being performed by others.

Progress: This is a new project, therefore significant progress is not available.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00210-01	EVAL/MULTI-FUNCTION MACHINE FOR SANITARY LANDFILL OPERATIONS	V. L. HAMMOND BATTELLE NORTHWEST RICHLAND, WASHINGTON

Objectives: The objective of this program is to perform comprehensive evaluation of a multi-functional machine for use in sanitary landfill operations. Included in the evaluation will be:

Analysis and demonstration of the machine's capability to perform solid waste moving and compacting operations in area, pit, trench, and open face type landfills.

Comparison of the multi-functional machine's capabilities with those of crawler-type tractors for performing landfill operations.

Evaluation of landfills produced by a multi-functional machine and crawler tractors.

Determination of the size of community and associated solid waste characteristics that can be serviced by one or several sites, using a single multi-functional machine.

Progress: The engineering review of the machine is in progress and refurbishing of the machine has been started. An engineering technician is now being used full-time on the renovation and modification of the machine.

Work has begun on the population forecast study, industrial growth, and technology forecast for the state of Idaho. Some data have been collected that provide a good base line.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00222-01	WASTE PESTICIDES MANAGEMENT	ROBERT L. GOULDING ENVIRONMENTAL HEALTH SCIENCES CENTER OREGON STATE UNIVERSITY CORVALLIS, OREGON

Objectives: Principal objectives of this project will be to develop technical information and a management system for reduction of pesticide waste problems.

The basic strategy underlying the program will be to utilize the potential of the soil for biological and physical degradation of chemicals. Suitable land is available with low use potential and with geological features assuring restriction of chemical wastes to the site of application, providing airborne transport is adequately restricted.

To be acceptable, any system developed must be proved capable of degrading a given chemical waste to non-toxic products within a useful time interval, permitting reapplication of additional waste or diversion of the land for other use.

The product of two principal waste sources will be studied: (1) The by-products of pesticide manufacturing and formulating industries and (2) The accumulations of containers generated by agricultural usage of pesticides. Solution of the latter problem requires decontamination and reuse or disposal of the containers as well as degradation of their unused residual content.

Progress: This is a new project, therefore significant progress is not available.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00227-01	IMPROVEMENT BENEFITS TO SMALL COMMUNITY'S SOLID WASTE SYSTEM	WALTER ANDERSON CITY OF HELENA HELENA, MONTANA

Objectives: To purchase, install, and maintain bulk containers as justified to reduce operating costs and improve sanitary and environmental conditions.

To purchase, install, and maintain residential storage containers in a selected portion of the city to reduce operating costs and improve sanitary and environmental conditions.

To develop a sanitary landfill site, at a location centrally located within the city, so that the land may ultimately be used for recreation or other municipal purposes.

To establish a detailed system of record keeping and cost accounting. Each of the above objectives will be analyzed to determine economic, sanitary, and environmental benefits.

Progress: This is a new project, therefore significant progress is not available.

EC-00233-01	DEMONSTRATION OF EQUIPMENT FOR BULKY WASTE DISPOSAL ON COUNTY BASIS	RONALD B. FRIEDMAN DUTCHESS COUNTY POUGHKEEPSIE, NEW YORK

Objectives: The primary objective is to demonstrate that after intensive investigation and evaluation of available and possible equipment that bulky wastes can be significantly reduced in volume by mobile equipment in an orderly manner through the supervision and operation by one agency instead of 26 agencies, thereby demonstrating to local municipalities and agencies that a joint effort waste disposal program is more economical and practical than individual efforts.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION

EC-00233-01 (Continued)

Through this program, it will be possible to integrate and coordinate the bulky waste disposal efforts of the Poughkeepsie Model Cities Program, the Poughkeepsie and Beacon Urban Renewal Programs, the Dutchess County Rodent Control Program and the Dutchess County Permanent Mosquito Control Program. It is further intended to prolong the life of a sanitary landfill.

The secondary objective will demonstrate that an area need not be urban and compact in character to achieve satisfactory economical disposal of bulky wastes in meeting all Federal, State and local air pollution and refuse disposal regulations. Indiscriminate dumping of bulky wastes will be eliminated because through shredding or compacting with readily available equipment, the refuse disposal sites will accept bulky wastes. It will further be possible to demonstrate that shredding or compacting may be an economical and feasible means of disposal for all solid wastes generated.

Progress: This is a new project, therefore significant progress is not available.

EC-00237-01

LAND RECLAMATION, EDUCATION TRAINING DEMONSTRATION PROJECT

GERALD A. NEELY
METROPOLITAN PLANNING COMMISSION
KANSAS CITY, MISSOURI

Objectives: The objective of the project is to demonstrate what a sanitary landfill is, how it can be developed and operated in conjunction with a Model Cities Urban Renewal Program, to provide an on-site training program for sanitary landfill operation and administrative personnel, and to promote intergovernmental cooperation and provide an education facility.

Progress: This is a new project, therefore significant progress is not available.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00238-01	HOME STORAGE & COLLECTION CONCEPTS OF SOLID WASTE	ALFRED H. BECK CITY OF KANSAS CITY KANSAS CITY, MISSOURI

Objectives: The objective of this project is to demonstrate several different systems and concepts for the storage and collection of solid wastes in typical neighborhood areas. Rather than seeking a single "standard" system, efforts will be made to identify various systems that would provide optimum performance in neighborhoods of different socio-economic strata. Factors to be considered are suitability (performance/effectiveness), feasibility (available resources) and acceptability (within normal local government constraints). Measurement will be made of the relative impact of the various systems and concepts, as well as the entire demonstration, upon other municipal agencies and services. Findings and evaluations will be published and made available to all agencies at all levels of government that are involved in solid waste storage, collection and disposal.

Progress: This is a new project, therefore significant progress is not available.

EC-00239-02	UNI-MELT WASTE DISPOSAL SYSTEM	CHARLES C. SPENCER COUNTY OF ERIE BUFFALO, NEW YORK

Objectives: The objective of the project is to demonstrate the capability of the Uni-Melt system to dispose of mixed combustible and noncombustible municipal refuse and to develop engineering data and scale-up perameters to provide a basis for practical applications of these systems throughtout the county and country. After the completion of the project an operable facility will be provided for Erie County to dispose of municipal refuse on a continuing basis. This facility will be expandable to dispose of greater amounts of refuse on a more economical basis. It will provide an operating facility which can be used on a rental basis for by-product and reclamation studies of molten slag residues.

Progress: There is no significant difference in FY 69 from that in FY 68.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00240-01	DEMO-HIGH TEMPERATURE VORTEX INCINERATION SYSTEM	ANTHONY W. FRAPS CITY OF SHELBYVILLE SHELBYVILLE, INDIANA

Objectives: The objective of this project is to demonstrate that a compact waste disposal system utilizing a shredder and high temperature Vortex incinerator can be used to dispose of the solid wastes of a small, rural city and the surrounding county economically with less ash residue than with conventional methods without violating air pollution regulations.

Progress: This is a new project, therefore significant progress is not available.

EC-00241-01	DEVELOPMENT AND USE OF REGULATIONS FOR COLLECTION OF AUTO HULKS	FRED K. HEMPHILL CITY OF GAINESVILLE GAINESVILLE, FLORIDA

Objectives: To develop equipment that is more efficient for the removal of abandoned automobiles, applicances and other bulky solid waste and to transport them to an approved disposal area. With proper equipment, the above items can be removed by the use of one employee where under existing methods four to six employees and at least two pieces of equipment are required.

To develop and impiement effective legal procedures, ordinances, and rules and regulations to control the placement, abandonment, and keeping of junk, abandoned automobiles and applicances on public and private property.

Progress: This is a new project, therefore significant progress is not available.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00244-01	IMPLEMENTATION OF METRO-SOLID WASTE MANAGEMENT PLAN	TOM CHENOWETH METROPOLITAN AREA SOLID WASTE AGENCY DES MOINES, IOWA

Objectives: The purpose of this program is to demonstrate the implementation of a Metropolitan Solid Waste Management Plan. The plan as set forth in the "Report for the Des Moines Metropolitan Area - Collection and Disposal of Solid Waste" - dated 1968 is desirous of being promulgated by establishing the administrative procedures, hiring key personnel and developing the detailed refinements required to bring into being the administrative framework for establishing an efficient solid waste system for a metropolitan area. The demonstration will establish guide lines, criteria and methodology having regional and national application as well as providing an efficient solid waste management system for the project area.

Progress: This is a new project, therefore significant progress is not available.

EC-00246-01	WASTE CLAMSHELL RECYCLING AS OYSTER CULTCH	RICHARD B. HOWELL DELAWARE STATE BOARD OF HEALTH DOVER, DELAWARE

Objectives: To demonstrate an improved method of disposal of waste sea clam shells that will eliminate public health hazards, nuisances, community unrest, and associated social and political problems which have plagued coastal communities where land disposal of such wastes has been practiced. The physical and economic feasibility of utilizing waste sea clam shells, through deposition into the marine environment, specifically estuarine waters, will be demonstrated. The project will be programmed in such a manner that oyster spat will be afforded optimal usage of the clam shells as cultch material on which to set. The project will be designed to determine the optimum size and volume of planted clam shells for use as oyster cultch; to determine the most suitable form in which shells may be planted; and to demonstrate that no water or air pollution results from proper marine disposal of these solid wastes.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PROGRESS	PROJECT DIRECTOR & LOCATION
EC-00246-01 (Continued)	The successful completion of the work set forth in this grant will enable elimination of open dumping of putrescible clam shells along with associated odors and vector harborage and will free coastal land areas for higher and more attractive land uses. It is anticipated that upon completion of this project it will have shown the practicality of using the material as oyster cultch and generated a market for this waste product which will cover disposal costs. Progress: This is a new project, therefore significant progress is not available.	
EC-00247-01	SOLID WASTE MANAGEMENT - SURVEY & ANALYSIS OF THE PRIVATE SECTOR	HAROLD GERSHOWITZ NATIONAL SOLID WASTES MANAGEMENT ASSOCIATION WASHINGTON, D.C.
	Objectives: To assess the magnitude of the contribution of the private contractor in the collection and disposal of solid wastes throughout the nation. The study is being undertaken with a view toward identifying the extent to which the private contractor is performing solid wastes collection and disposal service in the United States. The study will also determine the type and amount of waste by generator category. Progress: This is a new project, therefore significant progress is not available.	

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00002-03	WEST VIRGINIA PLANNING GRANT	O. R. LYONS WEST VIRGINIA STATE DEPARTMENT OF HEALTH CHARLESTON, WEST VIRGINIA

Objectives:

1. To complete development of a state plan for solid waste disposal.
2. To continue working with local governmental agencies for development of solid waste disposal systems.
3. To spot-check conditions when necessary to update data for local use. Special surveys will be made where indicated.
4. To assist in the development of legislation applicable statewide.
5. To continue to disseminate information to the public.
6. To continue training local and staff personnel to increase their skills.

EC-00003-03	STATE OF VIRGINIA PLANNING GRANT	R. E. DORER VIRGINIA STATE HEALTH DEPARTMENT RICHMOND, VIRGINIA

Objectives: A comprehensive study of current collection and disposal of solid waste practices in all counties, cities and towns in Virginia. There are 96 counties, 34 cities, and 196 towns. Plans will be developed to bring practices up to an acceptable standard, including the development of combining equable jurisdictions into unit plans. Local plans will be for a 20-year period, giving consideration to such things as population trends, urban and industrial expansion, and economic factors associated with solid waste.

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EC-00003-03 The project will develop proposed regulations and/or legislation needed to implement comprehensive statewide solid waste control. Acceptable public health standards for all phases of solid waste control will also be developed.

This project also provides technical and consulting assistance to public works, local health departments, and other operating agencies. Consulting advisory assistance will be available to governing bodies to implement plans and carry out adequate operations. Training of municipal operators and local inspectors is another objective of this project.

EC-00006-03 STATE OF NORTH CAROLINA PLANNING GRANT

SIDNEY H. USRY
NORTH CAROLINA STATE BOARD OF HEALTH
RALEIGH, NORTH CAROLINA

Objectives: Finalize long-range planning with appropriate legal jurisdiction. Promulgate necessary rules and regulations and legislation to carry out an acceptable solid waste program within the State of North Carolina.

Secure acceptance of plans and assist appropriate legal jurisdictions with implementation of the long-range planning.

EC-00007-03 STATE OF NEW JERSEY PLANNING GRANT

ARTHUR W. PRICE
NEW JERSEY STATE DEPARTMENT OF HEALTH
TRENTON, NEW JERSEY

Objectives: To determine the feasibility of using controlled overfire air, open-pit incineration as a reduction and disposal method for bulk refuse, with bulk

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EC-00007-03 (Continued) refuse being defined as private and public bulk solid waste resulting from building demolition and/or route clearing. It is also the intent of this study to give detailed attention to the compliance of the pit incineration disposal method with New Jersey State Department of Health Standards, both Air Pollution Control and Solid Waste Program units.

EC-00008-04 STATE OF CALIFORNIA PLANNING GRANT

PETER A. ROGERS
BUREAU OF VECTOR CONTROL
STATE DEPARTMENT OF PUBLIC HEALTH
BERKELEY, CALIFORNIA

Objectives: After the report containing the basic data has been completed, an attempt will be made to project the future quantities and environmental effects based on existing technology and management plans. These two sets of conditions will be used to develop the conceptual plans for immediate and long-range programs for comprehensive solid waste management. Specific activities will include the development of preliminary standards, controls, and programs together with a timetable for orderly achievements.

The study's Technical Advisory Committee will be utilized to obtain internal reaction and it is planned that extensive coordination will be carried on with appropriate state and local agencies. Particular consideration will be given to consolidating the varied and special interests of those state agencies affecting solid waste management.

EC-00010-03 PLANNING GRANT STATE OF LOUISIANA

JOHN T. TRYGG
LOUISIANA STATE BOARD OF HEALTH
NEW ORLEANS, LOUISIANA

Objectives: 1. To establish responsibility for the planning and implementation of solid waste activities at State, District, County and Municipal levels.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION

EC-00010-03 (Continued)

2. To evaluate current problems and forecast solid waste disposal needs.

3. To develop a long-range plan (20 years or longer) coordinating solid waste activities at all levels into a feasible, comprehensive and cohesive plan for the State, Region, County and District.

4. To provide guidelines for implementing solid waste management plans and provide continuing technical reference and services through which solid waste disposal agencies may obtain guidance.

5. To evaluate existing laws, rules and regulations at State and local levels to develop a legislative plan and schedule for providing the necessary management, planning, fiscal and implementation authority to successfully cope with present and anticipated solid waste problems at all levels.

EC-00011-03 STATE OF OHIO PLANNING GRANT

C. M. ROBINSON
OHIO DEPARTMENT OF HEALTH
COLUMBUS, OHIO

Objectives: (1) Improved operation of acceptable solid waste disposal sites and facilities. (2) Improved methods for on-site disposal of industrial wastes not covered by existing legislation. (3) Development of training program for operating personnel. (4) Development of testing programs to be used in critical areas. (5) Improved legisltation. (6) Development of better area-wide solid waste management practices. (7) Better informed public. A detailed outline of the plan has been prepared.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00012-03	STATE OF RHODE ISLAND PLANNING GRANT	WALTER J. SHEA RHODE ISLAND DEPARTMENT OF HEALTH PROVIDENCE, RHODE ISLAND

Objectives: To plan for the development of a comprehensive solid waste disposal plan sufficient to permit the orderly development of solid waste disposal systems equal in measure or extent to the anticipated local, state, and regional developments in the foreseeable future and to provide for the continuing proper implementation and management of the resultant solid waste disposal plan which would include but not be limited to:

1. The establishment of a full-time planning unit for solid waste disposal within the Rhode Island Department of Health.

2. The evaluation of current problems already determined and solid waste disposal needs already forecast in a survey of the solid waste disposal problem in the State was completed for the Rhode Island Development Council in August 1965.

3. The development of a long-range plan for coordinating all local and regional solid waste disposal planning into a feasible, comprehensive, and cohesive plan for the entire state; and the furnishing of technical assistance to local and regional jurisdictions toward that end.

4. The development of guidelines for the implementation of the solid waste disposal plan and the furnishing of continuing technical assistance and guidance tc solid waste disposal agencies.

5. As the progression of the implementation of the solid waste disposal plan indicates--to formulate a schedule of termination of unapproved solid waste disposal methods.

6. The drawing and recommending of enactment of legislation to permit adequate governmental regulation and support of effective solid waste disposal methods; and to establish and support proper standards for solid waste disposal.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00013-02	STATE OF HAWAII PLANNING GRANT	SHINJI SONEDA DEPARTMENT OF HEALTH, STATE OF HAWAII HONOLULU, HAWAII

Objectives: This grant is for a one-year extension to the Hawaii State Solid Waste Planning Grant which is scheduled to expire on June 30, 1969. The object of the extension is to provide the additional planning work which is required to fill out the framework of the plan so that it will contain a viable, flexible, fully documented implementation program which will be responsive to the feedback it will receive as it is carried out.

EC-00014-03	STATE OF OREGON PLANNING GRANT	W. B. CULHAM OREGON STATE BOARD OF HEALTH PORTLAND, OREGON

Objectives:

1. To strengthen and enlarge current solid waste activities which now exist within the Vector Control Program of the Division of Sanitation and Engineering, Oregon State Board of Health.

2. To evaluate, in detail, current disposal practices and problems in each community or area of Oregon, including promiscuous dumping problems where prevalent.

3. To forecast future needs of sanitary solid waste disposal, considering the total ecology (demography, geology, meteorology, transportation systems, etc.) of each distinctive area in Oregon. Ecologically distinct regions will be precisely delineated during the evaluation study.

4. To develop long-range plans for sanitary handling of solid waste for each region.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00014-03 (Continued)	5. To gain acceptance of the plans by the governmental jurisdictions involved in each region. 6. To strengthen and enlarge upon chains of communication between the planning agency (Oregon State Board of Health) and local political entities, so that the master plan developed may be implemented. 7. To implement the plans through consultation and technical assistance by the Oregon State Board of Health. A plan for solid waste management in the State is complete.	
EC-00015-03	STATE OF IDAHO PLANNING GRANT	ROBERT P. OLSON IDAHO DEPARTMENT OF HEALTH BOISE, IDAHO
	Objectives: The prime concern is the direct and indirect adverse effect of solid waste on human health. Specific goals are to recognize, evaluate, control, and if possible, to eliminate the causes of the adverse effects of this waste on man's total environment. This concern will involve factors effecting animal life, plant life, the effects on the human senses, along with social, political and economic impacts of these wastes and of programs to control them.	
EC-00018-03	STATE OF OKLAHOMA PLANNING GRANT	LOYD F. PUMMILL OKLAHOMA STATE DEPARTMENT OF HEALTH OKLAHOMA CITY, OKLAHOMA
	Objectives: For this third period it is expected that the surveys will be completed for the entire state before this period starts. This period will be utilized in analyzing the information by the staff and by consulting services. An advisory	

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION

EC-00018-03 (Continued)

committee will be formed and advised on all the information gathered including not only survey results but information gathered on present laws, present practices, and information from geographic and geologic studies. A preliminary report will be written which will include proposed legislation. After committee discussions appropriate changes will be made in the report.

The report will then be presented to various subcommittees of the State Legislature, which meets from August to December, for introduction of bills when the Legislature convenes in January 1969. Appearances will be made, at appropriate times after the Legislature convenes, before various subcommittees and interested groups, while the Legislature is in progress. Simultaneous and parallel with this activity appearances and talks before various city councils will be made to explain the report and to promulgate proper ordinances at the local level. The final report will include the results of new legislation and progress made in the three-year span of the planning grant.

EC-00019-02 STATE OF NEW MEXICO PLANNING GRANT

BRYAN E. MILLER
HEALTH & SOCIAL SERVICES DEPARTMENT
SANTA FE, NEW MEXICO

Objectives: A coordinated plan to increase New Mexico's educational and public information program in solid waste disposal will be developed and extended into community, agriculture, industrial and recreational fields for the purpose of correcting disposal deficiencies. Evaluation of all data collected from surveys of all communities, agriculture, industrial and municipal weighing programs has been analyzed for use in proposed state plans. Land availability and suitability studies will be conducted for location and reservation of future disposal sites to be carried out in conjunction with Federal and State land agencies. Eight major open dumps in the

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EC-00019-02 (Continued)

State have been converted to sanitary landfills. Existing legislation and regulations being reviewed by Legal Division Solid Waste legislation will be drafted for review by Advisory Committee prior to 1969 legislature. A plan is being developed for enforcement of legislation on solid waste, if enacted. Short courses in principles of solid waste disposal operations will be developed for State, Federal and industry personnel. The school will be coordinated with air and water pollution. A preliminary draft of model county and regional plans will be developed. Staff personnel attendance at national conferences on solid waste disposal will be part of the continued training. Model ordinances will be prepared in line with enacted legislation and Department regulations for distribution to municipalities and counties. A plan outline has been prepared.

EC-00020-03 STATE OF PENNSYLVANIA PLANNING GRANT

WILLIAM BUCCIARELLI
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HEALTH
HARRISBURG, PENNSYLVANIA

Objectives: To bring the project in line with the state fiscal year for ease in fiscal accounting. To provide direct assistance to municipalities in developing local and regional solid waste management plans. To review the data submitted in Phase 2 of the contract with Drexel Institute of Technology (Glysson) and integrate it into our statewide solid waste program. To initiate the analysis of agricultural-industrial data by locality, type of waste, and method of storage, collection,

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00020-03 (Continued)	transportation, processing and disposal. Finalize the 03 year reports to be included in the statewide solid waste management plan. A preliminary draft of the plan has been completed.	
EC-00021-03	STATE OF NEW YORK PLANNING GRANT	WILLIAM WILKIE NEW YORK STATE DEPARTMENT OF HEALTH ALBANY, NEW YORK

Objectives: Develop a comprehensive statewide plan for satisfactory transportation, treatment and disposal of domestic, commercial, industrial, agricultural and institutional solid wastes, gearing this plan to a developing State, integrating this plan into an overall comprehensive plan for the development of the State and taking into account the air, water and land resources which make up our environment, and instituting such protective measures to provide for a habitable, healthy environment and prevent public health hazards and nuisances. A preliminary plan draft is complete.

EC-00022-03	PLANNING GRANT - STATE OF GEORGIA	W. SCOTT SPRINKLE GEORGIA DEPARTMENT OF PUBLIC HEALTH ATLANTA, GEORGIA

Objectives:

1. To establish a full-time planning agency in Georgia for solid waste disposal, which will concern itself with district and county problems, as well as with the State as a whole.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION

EC-00022-03 (Continued)

2. To assess the current solid waste disposal program in Georgia and anticipate future needs.

3. To develop and publish a long-range plan for solid waste disposal in Georgia, coordinating plans at county, district and regional levels, as well as for the State.

4. To involve in the planning and implementation of a solid waste disposal program the public and private agencies, local and state wide industrial, commercial and civic interests who are concerned with the problems and solutions to solid waste. disposal.

EC-00023-03 STATE OF CONNECTICUT PLANNING PROJECT

DAVID C. WIGGIN
CONNECTICUT STATE DEPARTMENT
OF HEALTH
HARTFORD, CONNECTICUT

Objectives: A film produced by this Department entitled "Sanitary Landfill -- Open Dump Conversion" is continually being shown both in and outside of Connecticut. During the period of January 1, 1968 through December 31, 1968, it was shown twenty times in Connecticut and at least fourteen times outside of the State. Twelve hundred copies of the report "Study of Refuse Disposal Methods in Connecticut" were printed and distributed to all members of Study Groups and of the General Assembly, as well as regional planning agencies, mayors, town managers, directors of health and first selectmen in Connecticut cities and towns. Approximately 278 meetings and conferences were held with State, city and town officials, consulting engineers, private individuals and the public to provide them with information concerning State statutes, regulations and requirements concerning solid waste handling and disposal. Sixty-three talks were also given to various interested groups on satisfactory methods of disposal, comparative costs and new approaches being considered or demonstrated.

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EC-00024-03	MAINE STATE PLANNING GRANT	EARLE W. TIBBETTS MAINE DEPARTMENT OF HEALTH AND WELFARE AUGUSTA, MAINE

Objectives: The ultimate goal is to provide improved methods of solid waste disposal within the State. In order to accomplish the goals a State solid waste plan must be formulated and implemented. Maine has received first and second year grants and is presently in the outline stage of a State solid waste plan. Project objectives are completion of the State plan and implementation of the plan. A study will be made of industrial and agricultural solid waste in the State and included in the State plan.

There appears to be considerable need for giving some direction for disposal of industrial and special wastes. It will be necessary to gather more complete information to determine all of the potential problems in order to accurately plan for disposal of these solid wastes.

EC-00025-02	STATE OF FLORIDA PLANNING GRANT	NICK MASTRO FLORIDA STATE BOARD OF HEALTH JACKSONVILLE, FLORIDA

Objectives: To survey the solid waste disposal practices throughout the State of Florida, noting specific problems encountered. The information derived from this survey will be used to prepare a comprehensive statewide solid waste disposal plan covering: (a) incorporated areas, (b) urban unincorporated areas, (c) non-urban areas. Attempts will be made to take into account industrial solid waste as well as those of a domestic nature.

The State Board of Health has exclusive statewide jurisdiction over solid waste disposal. Contact with other State agencies who have or might have interests

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION

EC-00025-02 (Continued)

in such matters will be made to determine possible effects of other agencies, such as the Industrial Commission and Development Commission. It should be noted that the State Board of Health also has responsibility for air and water pollution control throughout the State.

Review of existing laws and regulations will be made to determine if any changes are needed. If changes are indicated, action will be carried out to prepare a draft of necessary corrective action, such as proposed rules or legislation.

EC-00026-03 STATE OF TENNESSEE PLANNING GRANT

J. L. CHURCH
TENNESSEE DEPARTMENT OF PUBLIC HEALTH
NASHVILLE, TENNESSEE

Objectives.

1. Collection and analysis of data concerning existing solid waste disposal practices.
2. Development of local, regional and State plans.
3. Development of competent planning consultant service at the State level.
4. Review and development of legislation for implementation of developed plans.

EC-00027-02 COMMONWEALTH OF PUERTO RICO PLANNING GRANT

SANTOS ROHENA BETTANCOURT
DEPARTMENT OF HEALTH
COMMONWEALTH OF PUERTO RICO
SANTURCE, PUERTO RICO

Objectives: The overall objective of this project is to expand the existing solid wastes planning study in order to develop a long-range comprehensive solid wastes management plan for Puerto Rico with sufficient flexibility to accommodate changing

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION

EC-00027-02 (Continued)

technology and needs. The following is part of the program to satisfy this objective:

1. Incorporate a comprehensive management structure in the program.

2. Further develop the technical and management capabilities of the existing solid wastes management staff of the Department of Health.

3. Include aspects of economic and demographic projections in the study.

4. Utilize fully all interdisciplinary considerations in the development of the management plan.

5. Prepare recommendations for immediate technical improvements and authoritative action after the first year of study.

EC-00028-03 STATE OF MONTANA PLANNING GRANT

CLAIBORNE W. BRINCK
MONTANA STATE BOARD OF HEALTH
HELENA, MONTANA

Objectives: Continue municipal solid waste survey to include all pertinent information necessary for plan development. Will complete survey portion by 1969. Extend the solid waste survey to include agricultural as well as industrial wastes.

Review existing laws and recommend revisions as well as new legislation that may be needed.

Coordinate solid waste program with other programs such as water and air pollution and comprehensive health planning.

Develop solid waste training material. A plan draft is in preparation.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00029-03	STATE OF NORTH DAKOTA PLANNING GRANT	EVERETT LOBB NORTH DAKOTA STATE DEPARTMENT OF HEALTH BISMARCK, NORTH DAKOTA

Objectives: Develop a method of solid waste disposal for North Dakota communities that they can afford, will support, will eliminate hazards to the public health, and that will not pollute water, air, or land.

EC-00030-02	WASHINGTON, D.C. PLANNING GRANT	PAUL W. REED DEPARTMENT OF SANITARY ENGINEERING WASHINGTON, D. C.

Objectives: Establish a preliminary and a final overall comprehensive plan for the improvement of onsite (residential, commercial, institutional) refuse storage and/or reduction facilities; modern and improved methods of refuse collection by both public and private conveyances; and adequate and economically feasible methods for the complete and final disposal of all solid wastes produced within the District of Columbia. Develop and closely coordinate solid waste planning activities with the Metropolitan Washington Council of Governments (COG) through the Regional Sanitary Advisory Board and with individual area jurisdictions including the various federal agencies as may be appropriate.

It is the purpose of this project to collect and analyze data on the various aspects of solid waste management to permit the development of planning for proper and effective solid waste management, coordinated with adjacent States and regional and local planning activities, consistent with the protection of the public health and including the consideration of such factors as population growth, metropolitan development, land use planning, water, land, and air pollution, rodent and insect control and the feasibility of regional disposal programs.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00031-03	STATE OF TEXAS PLANNING GRANT	DAVID M. COCHRAN TEXAS STATE DEPARTMENT OF HEALTH AUSTIN, TEXAS

Objectives:

1. To provide current data relative to the status of solid waste disposal practices in the State of Texas.

2. To determine the extent of air and water pollution resulting from inadequate methods of solid waste disposal.

3. To stimulate and accelerate programs in research and development of improved methods of solid waste disposal.

4. To promote the use of the best available method of refuse disposal in all cities, municipalities and communities in Texas.

5. To establish a satisfactory municipal refuse education program.

EC-00032-02	STATE OF ARKANSAS PLANNING PROJECT	SIDNEY S. FITZGERALD ARKANSAS POLLUTION CONTROL COMMISSION LITTLE ROCK, ARKANSAS

Objectives: Approximately 90 percent of the industrial survey has been completed as survey forms sent out by the air pollution section have yielded enough information in order that field work which had been anticipated will be cut to a minimum. A method of analysis and evaluation must be found in order to use this information as it covers only a portion of the State's industry.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION

EC-00032-02 (Continued)

Work is being done with the air and water pollution programs in an effort to eliminate open burning and dumping of wastes into streams and places where ground water pollution may occur. Cities are encouraged to investigate the possibility of using the sanitary landfill or other methods of waste disposal.

Soil and water table maps for a portion of the State have been acquired from other agencies to assist in the planning and locacion of sanitary landfill sites. Maps for the entire State were not available. An outline of the State Plan has been prepared.

EC-00033-03 STATE OF UTAH PLANNING GRANT

LYNN M. THATCHER
UTAH STATE DEPARTMENT OF HEALTH
SALT LAKE CITY, UTAH

Objectives: Effect improvement in existing methods of disposing of solid waste, encourage an areawide cooperative approach to metropolitan areas of the State and prepare a plan for future guidance looking forward to elimination of open burning and open dumps and toward general beautification of the State, to develop a Code of Regulations for adoption by the State Board of Health and to implement existing State statutes in the control of Solid Waste Disposal. Instigate a method for effective, orderly implementation of solid waste disposal plans, and provide technical assistance to solid waste disposal agencies.

EC-00034-02 STATE OF MINNESOTA

JOHN P. BADALICH
MINNESOTA POLLUTION CONTROL AGENCY
MINNEAPOLIS, MINNESOTA

Objectives: The overall objective of this project is to prepare a comprehensive solid waste disposal plan for the Twin Cities Metropolitan Area which will be an important part of the Minnesota State solid waste disposal plan. The specific result of this grant program would be the compietion and adoption by the Metropolitan Council of the comprehensive plan for solid waste disposal in the Metropolitan area. It is the intent of the Pollution Control Agency and the Metropolitan Council to work closely with the counties through this program.

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00035-02	STATE OF KANSAS PLANNING GRANT	IVAN F. SHULL KANSAS STATE DEPARTMENT OF HEALTH TOPEKA, KANSAS

Objectives: This planning grant is to be used to fund a study of the solid waste management needs for the State of Kansas. Once these are determined legislation will be sought to implement practical solutions to these needs. With a statement of the needs and the legislative authority an ongoing solid waste management plan will be formulated to promote orderly solutions to the solid waste problems in Kansas; promote and encourage technology aimed at making more economical services available to the people of Kansas; promote and encourage means of reducing the total amounts of solid waste to be handled; and provide the amounts of regulation and surveillance necessary to protect the health and welfare of the citizens of Kansas and to clean up and enhance the quality of their environment. A preliminary plan draft is in preparation.

EC-00037-02	STATE OF DELAWARE PLANNING GRANT	DONALD K. HARMESON DELAWARE STATE BOARD OF HEALTH DOVER, DELAWARE

Objectives: To develop a practical and sanitary storage, collection and disposal system which will combine areas that currently do not possess funds and knowledge to operate adequately into large scale operations which are financially able to support a full-time sanitary solid waste disposal organization. This regional approach to statewide comprehensive planning will provide adequate financial resources for establishment of sanitary disposal facilities. Other planning objectives will be to consider the problem well into future years and ensure thorough coordination with other agencies which are concerned with solid waste disposal. Disorganized, inadequate and unsanitary conditions will be prevented from occurring in the future since planning and evaluation will be a continuous process.

The program will include overcoming social and government stagnation, through a dynamic solid waste education program, leading to development and enactment of adequate

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00037-02 (Continued)	legislation and regulations that will eliminate open burning and dumping. It will include organizing the State into economical "regional disposal areas" and establishment of sanitary disposal facilities for these areas. Establishment of refuse collection services where there are none and improvement of existing inadequate services will be necessary. The program will also include bringing the open dumps and inadequate landfills already in existence up to sanitary standards and closing those not to be utilized under the State Solid Waste Plan.	
EC-00038-02	KANSAS & MISSOURI INTERSTATE PLANNING GRANT	GERALD A. NEELY METROPOLITAN PLANNING COMMISSION KANSAS CITY REGION KANSAS CITY, MISSOURI
	Objectives: The purpose of this study is to prepare a program to manage the disposal of solid waste in the Kansas City metropolitan area (bi-state) for the next twenty years.	
EC-00041-01	OMAHA-COUNCIL BLUFFS INTERSTATE PLANNING GRANT	O. A. KINNEY OMAHA-COUNCIL BLUFFS METROPOLITAN AREA PLANNING AGENCY OMAHA, NEBRASKA
	Objectives: The proposed planning study is designed to fill the void between the preparation of the proposed plan developed in the first year and the actual implementation of the project. Activities planned during this study period are an active public information program to disseminate the consultant's recommendations to all affected political units of government and the general public and to prepare for a public hearing on the proposed solid waste management plan for the Omaha-Council Bluffs Metropolitan Area. Following the public hearing and adoption by the Council of Governments, coordination of activities will be necessary in development of documents, agreements, etc. to prepare for effectuating of a solid waste management program. A final disposal plan has been completed.	

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00045-01	STATE OF MISSISSIPPI PLANNING GRANT	V. T. HAWKINS MISSISSIPPI STATE BOARD OF HEALTH JACKSON, MISSISSIPPI

Objectives: Mississippi in planning for solid waste storage, collection and disposal will direct its activities toward the development of a comprehensive solid waste disposal plan of sufficient depth to permit the orderly development of a system in keeping with the anticipated local, county and State needs in the foreseeable future. To meet this objective:

1. A full-time planning agency for solid waste disposal has been established.

2. The agency will evaluate current problems as shown from survey results and forecast solid waste disposal needs.

3. Develop a long-range plan for coordinating all local, county and state solid waste disposal planning activities into a feasible, comprehensive plan for the entire State

4. Provide guidelines for implementing the solid waste disposal plan and provide continuing technical assistance and guidance to solid waste disposal agencies.

5. Develop and propose legislation needed to effectively implement the plan.

EC-00046-01	DEVELOPMENT OF MULTI-STATE DISPOSAL SYSTEM	JOHN J. LENTZ METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS WASHINGTON, D.C.

Objectives: This project will develop, for a multi-state region and through that interplay of technological analysis and political feedback which is uniquely available in a voluntary Council of Governments, an operable solid waste management system

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00046-01 (Continued)	capable of responding to long-term regional needs in a way that effectively eliminates pollution, maximizes the recovery of usable resources, and provides supplemental tangible and intangible economic benefits to all system participants. Throughout the study, currently existing inter-jurisdictional committees of agency managers and of elected officials will participate in critical decisions affecting the course of the remainder of the study.	
EC-00047-01	PRESENT & FUTURE OF SOLID WASTE DISPOSAL IN VERMONT	JOHN V. RICHARDS INTERAGENCY COMMITTEE ON NATURAL RESOURCES MONTPELIER, VERMONT
	Objectives: Study and investigate existing locations utilized for the purpose of solid wastes disposal, the methods employed to maintain the facility, the population served and a projection and plan for the future.	
EC-00049-01	OHIO-KENTUCKY-INDIANA INTERSTATE PLANNING GRANT	HARRY R. REED, JR. OHIO-KENTUCY-INDIANA REGIONAL PLANNING AUTHORITY CINCINNATI, OHIO
	Objectives: The basic goal of this project is to establish sanitary, efficient, and economical systems of solid wastes collection, processing, and disposal practices for the OKI region through comprehensive regional planning. In the context of this study, "solid wastes" will also include industrial sludge wastes and other problem wastes that cannot be recycled for further use, should not be injected into existing sewerage systems, or are particularly noxious or toxic.	

GRANT NO.	TITLE OF PROJECT & OBJECTIVES	PROGRAM DIRECTOR & LOCATION
EC-00050-01	TERRITORY OF GUAM PLANNING GRANT	T. H. YAMAMATO DEPARTMENT OF PUBLIC WORKS GOVERNMENT OF GUAM AGANO, GUAM

Objectives: The purpose of this project is to develop a solid waste management plan for the Territory of Guam including the significant armed forces population and activities. Since the Department of Public Works, Government of Guam is both the planning and implementing agency, substantial benefits can be derived from specific planning. Therefore, it is intended that the resulting territory solid waste plan will be designed for both broad planning objectives as well as provide for detailed operating management activities. Survey of solid waste conditions is in initial stage.

BUREAU OF WATER HYGIENE

Functional Statement

Establishes criteria and recommends standards of water quality for the protection of the Nation's health. Establishes certain standards for potable water used by carriers subject to Federal Quarantine Regulations. Develops and conducts comprehensive studies to determine the safe criteria and minimum standards for water quality. Establishes and maintains a national register of Public Water Supply Systems. Develops and conducts a program of technical assistance to public and non-profit institutions engaged in the operation of public water supply systems and use of water resources. Interprets the effects of water pollution upon man's health and carries out the responsibilities of the Department as a member of the Federal Water Resources Council.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00141-06 (UI-00127-06)	TRAVEL OF NITROGEN COMPOUNDS IN SOILS	GEORGE J. SCHROEPFER UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA

Objectives: The overall objectives of this research program are:

1. To determine the fundamental factors governing the movement of nitrogen contaminated water through soils,

2. To evaluate the factors tending to retard the movement or reduce the quantities of nitrogen compounds in soils, and

3. To evaluate the general travel limits of nitrogen under field conditions in the vicinity of underground pollution.

These factors affect the rate at which nitrogen compounds enter the ground water from various sources including fertilized and peat soils, livestock feeding and holding areas, solid waste landfills, waste stabilization ponds and effluents from waste water treatment or disposal systems. The evaluation of these factors has practical application in the location of a ground water supply with respect to these sources of nitrogen compounds.

The program of investigation involves the observation and analysis of physical, chemical, and microbiological actions resulting from the passage of nitrogen contaminated water through soils under various conditions. Investigations have been and will be conducted under both laboratory and field conditions, with the latter studies being directed toward existing waste water disposal systems and at least two controlled simulated soil absorption systems.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00141-06 (Continued)

Significant Results: A seven-year study dealing with the travel and transformation of nitrogen compounds in the soil-ground water environment was terminated in September of 1969.

Initial laboratory studies illustrated that even sandy soils have a considerable capacity to absorb ammonia nitrogen from percolating waters. The absorption capacity of a soil was found to be a function of pH and cation concentration of the applied solution. In the normal ground water pH range the nitrate ion was not absorbed or absorbed only slightly.

Ground water samples obtained in the immediate vicinity of waste water stabilization ponds provided data that indicate only a relatively small proportion of the influent nitrogen enters the ground water through percolation. Only a small portion of the percolated nitrogen is transformed to the nitrate form.

The results obtained from the study of actual soil absorption systems and simulated soil absorption systems all located in sandy soils common to the suburban area north of Minneapolis and Saint Paul, indicate that the ammonia nitrogen, discharged into the soil from the subsoil system, is absorbed on the soil and then oxidized by the nitrifying bacteria to the nitrate state which is not held by the soil and moves in the ground water. Nitrate nitrogen concentrations as high as 16 mg/l above background levels have been found as far as 140 feet from the point of discharge to the soil.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00241-01 (UI-00848-01)	BIOLOGICAL ACTIVITIES OF MARINE FUNGI	MELVIN S. FULLER UNIVERSITY OF GEORGIA ATHENS, GEORGIA

Objectives: The fungi are common in the oceans as saprophytes, parasites of algae, and invertebrate animals. This research has as its primary objective the acquiring of more precise information on the role of fungi in marine ecology. A group of little known coccoid organisms is to be examined morphologically, physiologically, and biochemically to determine both their evolutionary relationships and potential role in the marine environment. One such organism which may cause the gaping disease of oysters is being examined in greater detail. Two parasites each of marine algae and invertebrates are being subjected to detailed study to elucidate the (1) mechanism of host entry, (2) development of the parasites, and (3) the environmental and internal control of entry and development of the parasites.

Significant Results: The purposes of this project were primarily to (1) clarify relationships among a large group of little known, coccoid, eukaryotic marine microbes, some of which are known to be parasitic on commercially important marine animals; and (2) to examine a host-parasite relationship in detail.

Structurally, as observed with both the light and electron microscope, the zoospores of the flagellate members of the coccoid complex which have been examined are like the ones found in the biflagellate fungi. However, the habit of these fungi is quite different from that of the biflagellate fungi. Namely, the wall is composed of separate lamellae and the cell extensions previously homologized with rhizoids are not rhizoids but, instead, are cell excretions like those of Laybyrinthula. The biochemical analyses of the cell walls argue very strongly against including these marine forms in the fungi. The major polysaccharide in the walls of the form studied is a galactose polymer, separating the organisms from all of the fungal groups.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00171-01 (Continued)

Pythium marinum, parasitic on the red alga Porphyra, was isolated in axenic culture; thus allowing for the first time controlled studies of its biology. Laboratory infection of all species of Porphyra from the North American coasts was achieved. Factors controlling infection and spread of the disease were easily studied and could be quantitized under controlled laboratory conditions.

The ultrastructure of the host, parasite, and the host-parasite complex was described. No morphological features unique to their marine habitat were found.

Pythium marinum requires elevated amounts of Na^+, Mg^{++}, and Ca^{++} relative to the terrestrial members of the genus Pythium. The requirement for these ions was in the order of magnitude of concentrations of these ions found in sea water. By means of oxygen electrode studies, it was shown that the major effect of sodium was in mediating O_2 uptake for respiration.

Publications: None.

EC-00178-05 (UI-00158-05)

CIRCULATION ON THE CONTINENTAL SHELF

DEAN F. BUMPUS
WOODS HOLE OCEANOGRAPHIC INSTITUTION
WOODS HOLE, MASSACHUSETTS

Objectives: The investigator of this project has endeavored to delineate the horizontal motions in the circulatory system of the continental shelf of the east coast of the United States. With the generalized pattern in hand he is trying to work out the secular changes in the circulation and their causes. A Lagrangian technique will be used with drift bottles at the surface and sea-bed drifters at the bottom and make use of all the physical oceanographic, hydrological, climatic and meteorological data and theory to elucidate these motions.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00178-05 (Continued)

Significant Results: Examination of the residual surface drift, the mechanism by which the planktonic elements of plant and animal populations are carried long distances after spawning as are also contaminants introduced to the seas by outfalls, river effluents or barges, indicates five major circulatory systems on the continental shelf, each apparently controlled by one or two different factors. The Gulf of Maine cyclonic eddy appears to be controlled by the river run off and the strong tidal currents. The anti-cyclonic Georges Eddy which reaches its peak in May is controlled by the strong tidal currents and the horizontal temperature gradients which develop around the edges of the bank as a result of the vertical mixing over the bank in contrast to the vertical stratification which develops over the surrounding deeper water. Strong winds interrupt the normal pattern and contribute to advection practically down wind. The circulation over the Middle Atlantic Bight is controlled chiefly by the run off of the large river systems through the dynamic gradients resulting from gradients in the steric anomaly, but when the river run off is below normal in March, April or May, the primarily Southwesterly winds of summer may reverse or slow down the usual Southwesterly drift. Northeasterly winds augment the normal drift and frequently will drive portions of Virginian water across Diamond Shoals into the Carolinian province.

The surface drift off North Carolina is the least organized and is subject to short term advections dependent on the combination of forces acting on it at the time. Intrusions of Gulf Stream water at the bottom, frictional drag of the Gulf Stream and wind produce an Easterly drift, frequently interrupted close to shore by Northeasterly winds.

In contrast, the surface circulation over the shelf between Frying Pan Shoals and Cape Kennedy is influenced chiefly by the wind with some frictional drag by the Gulf Stream. Except for the three months of September, October and November, the surface drift is Northerly. During the three months of autumn, when the wind prevails out of the Northeast, the drift reverses, flows Southerly.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00178-05 (Continued)

In addition to the major circulation patterns which have in general a slight onshore component during the warm half of the year, there is an offshore component to the drift during the cold half of the year induced by the Northwesterly winds which prevail during much of that period. Monthly charts illustrating this concept have been prepared. It is quite apparent from these charts that there are certain places on the shelf where, as evidenced by the paucity of drift bottle recoveries, there is an offshore component at all seasons of the year. The head of Hudson Canyon off New York is conspicuous for its lack of recoveries. Analysis of the 1969 data should confirm the location of other "escape" sites.

Publications: Bumpus, Dean F. "Surface Drift on the Atlantic Continental Shelf of the United States - 1960-1967." Technical Report. Ref. No. 69-18. April 1969. Woods Hole Oceanographic Inst., Mass. UNPUBLISHED MANUSCRIPT - (Charts of Residual Surface Drift, month by month, for the eight year period 1960-1967 inclusive.)

EC-00181-03 (UI-00167-03)

SELECTED FACTORS INFLUENCING TASTE OF DRINKING WATER

ROSE M. PANGBORN
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA

Objectives: This laboratory study of selected factors influencing taste of drinking water has completed an investigation on the effect of solution temperature on the taste threshold, subjective intensity and degree of liking of varying concentrations of sodium chloride. The second phase will involve direct measurement of temperature in the mouth to ascertain the effect of solution temperature on thermal changes at the receptor sites. Additionally, samples of saliva will be collected to determine whether response to sodium compounds is related to the sodium content of the saliva.

The effect of carbonation of mineralized waters on resultant taste quality will be established, followed by studies on chlorinated and fluoridated waters.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00181-03 (Continued)

Significant Results: This study was designed to provide basic information on specific chemical, physical, and environmental factors which influence human detection, quantification, description, and acceptance of mineralized, chlorinated and fluoridated waters.

Solution temperature significantly altered the taste intensity of both natural waters and solutions of NaCl, $CaSO_4$, $CaCl_2$, $MgCl_2$, $MgSO_4$, Na_2SO_4, Na_2CO_3, $NaHCO_3$ with maximum intensities perceived at 22 and 37°C, and minimum taste intensity at the extremes of 0 and 55°C. The taste intensity of single and binary combinations of solutions of the foregoing minerals were quantified by a trained panel of judges. Chlorine at 0.88 ppm was readily identifiable in distilled water but much more difficult to perceive in Na_2CO_3 and in $NaHCO_3$, with intermediate results for the remaining compounds.

The addition of CO_2 gas at varying levels increased the perceived sourness of solutions and significantly increased salivary flow rates. Dissolved oxygen, on the other hand, had no effect on the taste of distilled water or on solutions of NaCl. The threshold for fluorine in distilled water was 10 times higher than amounts normally added to municipal drinking waters.

Solutions of the aforementioned minerals were used to prepare coffee, tea and an artificial fruit drink. In general, the best tea and fruit drink is obtained with distilled water, whereas the best coffee is obtained from waters with a low mineral content (200-500 ppm TDS).

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00182-04 (UI-00168-04)	TASTES AND ODORS IN WATER SUPPLIES	DAVID I. JENKINS UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

Objectives: The proposed research is a continuation and broadening of current work concerned with the identification and resolution of the source and nature of odorous compounds in natural waters. Emphasis is on the study of aquatic organisms as one of the major contributors to the problem of taste and odor in waters.

Conventionally the major odor categories include medicinal (phenolic-type compounds), fishy (nitrogen and sulfur-containing compounds), sulfidal and terpenoidal. Papers have been or are in the process of being written on the latter two categories: The sulfidal work involved odors (in descriptive terms) of rotten eggs, skunk, spoiled cabbage, etc., which are associated with simple mercaptans, sulfides and disulfides; the terpenoidal work involves odors (in descriptive terms) of earthy, woody, musty, floral, etc., and includes a variety of essential oils.

The earthy-smelling compounds isolated from blue-green algae and from various actinomycetes are not only the most widespread but also the most troublesome because extremely minute quantities render waters impotable. For this reason emphasis is being directed toward the resolution and identification of the earthy-smelling compounds coupled with the determination of their metabolic production for control aspects.

In addition to developing biological growth units and sampling techniques, microanalytical techniques have been used and developed involving gas chromatography, infrared spectroscopy, mass spectrometry and PMR.

Cooperation with the local water purveyor has enabled an exchange of samples and information on actual reservoir waters.

GRANT NO. | TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS | PRINCIPAL INVESTIGATOR & LOCATION

EC-00182-04
(Continued)

Significant Results: During fiscal year 1969, efforts have continued to be turned towards the identification of taste and odor-causing material in water supplies. Following on the work in which the sturcture of geosmin was partially resolved, a further earthy-smelling compound was isolated from several species of actinomycetes. This compound was shown to be 2-exohydroxy-2-methyl bornane. The research in fiscal year 1969 has also investigated methods for the removal of these odorous compounds by processes such as sorption on marcroreticular resins and oxidation with ozone. The latter process showed promise on a laboratory scale and studies are being initiated to investigate the oxidation of these compounds by ozone on a pilot plant scale.

Publications: Thomas, Jerome F., Medsker, Lloyd L. and Jenkins, David. "Odorous Compounds in Natural Waters. An Earthy-Smelling Compound Associated with Blue-Green Algae and Actinomycetes." Environmental Science and Technology. 2. pp 461-464. June 1968. University of California, Berkeley.

McGauhey, P. H., Pearson, E. A. and Thomas, Jerome F. "Eutrophication of Surface Waters." News Quarterly. XVIII - No. 3. July 1968. Sanitary Engineering Research Laboratory. University of California, Berkeley.

EC-00183-04
(UI-00172-04)

EMPIRICAL PREDICTION OF SAND FILTER PERFORMANCE

JOHN L. CLEASBY
IOWA STATE UNIVERSITY
AMES, IOWA

Objectives: In recent years, there has been a trend to higher filtration rates for sand filters used in municipal water treatment. However, no acceptable rational method has been developed to predict quantitatively the filtering characteristics of a given suspension of solids using a granular filter medium. Previous attempts at developing a filtrability index were done with thin filters which measure only surface removal effects and are thus not indicative of the depth removal obtained in

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EC-00183-04 (Continued)

a sand filter. Equations currently under study for prediction of the filter behavior have limitations that seriously restrict their usefulness. Data collected in this study will help make possible proper evaluation of such equations.

The objectives of this study are to develop a standard filtrability index to quantify the filtering characteristics of suspended solids on granular media. An apparatus has been constructed consisting of four small granular filters of different depth to measure the filtrate quality and head loss resulting from the filtration of various natural waters. The apparatus has been used to filter different suspensions in the laboratory and in various municipal treatment plants. At least two indices of filtration will be needed to describe a given suspension, one index of removal efficiency, and one index of head loss development. The data already collected and to be collected will be used to relate typical measured filtrability indices to design and operating guidelines, to test existing mathematical filtration models and to develop an improved model to predict filter performance. It is hoped that a standard measure of filtrability can be proposed as a result of this work.

Significant Results: An apparatus has been constructed consisting of four small granular filters of different depth to measure the filtrate quality and head loss resulting from the filtration of various waters. The apparatus has been used to filter different suspensions in the laboratory and in various municipal treatment plants. The conclusions reached thus far are:

1. Granular filtration is a very complex process. Different suspensions yield effluent quality and head loss curves of several shapes.

2. Due to this complexity, the probability of developing a rational filtration equation to fit all types of suspensions is rather remote, or a model may be so complex as to discourage use by operating personnel.

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EC-00183-04 (Continued)

3. Therefore, there is a need for a simple filtrability device and analysis technique to show how a filter is performing, to diagnose operating problems, to measure the effects of changes in pretreatment on filter performance, and to predict filter performance. Much of this information can be obtained by filtration of water through two shallow depth filters (3- and 6-inch filter media depth) using granular media. These filters can be operated at constant rate and effluent quality and head loss observations can be readily made. Observations of the shape and the spread of the filtrate quality versus time and head loss versus time curves for the two depths can reveal much about the filter performance, without any mathematical analysis.

4. It may be desirable to be able to calculate some numerical index of filtrability. A method for such a calculation has been proposed. The filtrability index is calculated from the data obtained on the two shallow depth filters. The calculations are simple to perform.

5. It is recommended that a device and procedure similar to that used and the filtrability index be considered by the AWWA as a standard test for the water industry.

Publications: Hsiung, Kou-ying, Cleasby, J. L., "Prediction of Filter Performance," J. of the Sanitary Eng. Divn. 94 (SA6):1043-1069. Iowa State University. Ames, Iowa. (1968).

EC-00185-02
(UI-00226-02)

BIOLOGICAL ALGICIDES

MIRIAM S. SHANE
UNIVERSITY OF DELAWARE
NEWARK, DELAWARE

Objectives: This project is concerned with the isolation from nature, that is, farm ponds, oxidation ponds, rivers, reservoirs, lakes, etc. of microorganisms which are

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EC-00185-02 (Continued)

antagonistic to or stimulate the growth and reproduction of blue-green algae. Isolated microorganisms including bacteria and viruses are being studied as to their effect upon the host cells under varied environmental conditions.

The results of this study should give a greater understanding of the ecological factors involved in algal blooms and supply a biological means of controlling such blooms.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: None

EC-00186-02 (UI-00242-02)

PARTICULATE-ORGANIC EFFECT-SENSORY QUALITY OF WATER

ROBERT A. BAKER
CARNEGIE-MELLON UNIVERSITY
PITTSBURGH, PENNSYLVANIA

Objectives: Preliminary studies have shown that highly electronegative particulates of colloidal dimensions escape conventional coagulation treatment and carry over into the finished water supply. It is hypothesized that these particulates serve as condensation nuclei for organic constituents. Absorbed microorganics are suspected of being responsible for taste and odor problems, particularly where formation of chloroorganic derivatives is possible. Laboratory studies will be conducted to test this hypothesis using selected organic-particulate-aqueous matrix systems. These waters will be coagulated under precisely controlled conditions. The sensory, chemical and physical characteristics of the treated water and associated particulate-organic will be measured. These results are expected to help control groups, industrial waste control and water-treatment plant operators, and chemical and environmental health researchers.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00186-02 (Continued)

Significant Results: The significant accomplishment of the ongoing research to date is (a) development of experimental techniques that will be important to many other investigators, and (b) discovering that generally-accepted concepts of sorption of common organic contaminants onto naturally-occurring clays are incorrect.

Initial studies were concerned with phenol and the clays, montmorillonite and kaolinite. Phenol is both a natural and a manmade contaminant. It induces water quality impairment at less than 1 part per billion concentration through formation of chlorophenolic compounds during water treatment. Montmorillonite and kaolinite are typical clays. The clays were specially prepared, highly purified and carefully classified for particle size. Mean particle size is approximately 0.2 microns. These small particles are measured by electron microscopy. Trace levels of phenol are monitored by radiochemical techniques. Vapor phase sorption characteristics of the phenol onto the clays was first defined so that thermodynamic properties of the system could be established. Then rate of sorption of the phenol from aqueous solutions was determined over a range of pH and found not to be reproducible. Experimental variation was eventually attributed to biological contamination. Once sterile techniques were devised, reproducibility was assured. In the absence of organisms, no phenol sorption occurs on these clays. This is an unexpected result. The few literature references related to organic sorption from aqueous solution are not at trace levels and yet even these data are quite variable. It is concluded that earlier investigators were not aware of the effect of biological contamination. Hence, the techniques and experimental procedure developed will be applicable in many disciplines. An investigation of the sorption potential for other important organic chemicals onto these clays is the subject of the current research.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00193-02 (UI-00330-02)	EXTRACTION OF ALGAE BY FLOCCULATIVE TECHNIQUES	MARK W. TENNEY UNIVERSITY OF NOTRE DAME NOTRE DAME, INDIANA

Objectives: The extraction of nuisance causing algae from various types of water, such as public water supplies and effluents from algal wastewater treatment systems, is of extreme importance if continued maintenance of high level water quality is to be ensured. This research proposes to investigate the feasibility of applying flocculative techniques to algal extraction. The primary objective is to study the basic mechanisms related to algal auto-flocculation and flocculation with added chemicals in order to obtain the necessary quantitative information to ensure the effective application of these techniques.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: None

EC-00194-02 (UI-00331-02)	SORPTION KINETICS IN FLOW THROUGH GRANULAR PARTICLES	DAVID W. HENDRICKS UTAH STATE UNIVERSITY LOGAN, UTAH

Objectives: This project focuses specifically on delineating the sorption (either ion-exchange or molecular physical absorption) kinetics for a mobile dissolved chemical species interacting with a fixed phase, consisting of granular sorbent particles. The stress is to obtain a generalized phenomenological description of the sorption kinetics--described in terms of local solid and liquid phase sorbate concentrations, and which will be reflected in the form of the rate law, the effects of temperatures competition for sorption sites by other species, nature of sorption site, and the nature of the rate limiting step in the reaction (i.e. solid or liquid phase

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EC-00194-02 (Continued)

diffusion). The results must be operational in terms of obtaining a solution for concentration profiles of sorbent in liquid and solid phases and the procedure for application must be based upon a limited amount of laboratory work--to be obtainable on a routine basis.

With the delineation on an operational basis of the above factors and methodology for describing sorption kinetics, one should be able to rationally assess concentration profiles in the liquid and solid phases. This should have application: (1) to investigative assessments and management of ground water contamination problems and (2) in optimizing the design and operation of ion-exchange and adsorption columns. The latter, of course, is becoming increasingly important as a step in tertiary treatment.

Significant Results: The first half of fiscal year 1968-69 was spent in setting up an experimental system and performing pilot testing to accomplish kinetic measurements for non-flow systems consisting of a granular sorbent and a dissolved sorbate. The experimental system developed is capable of handling fifteen kinetic systems simultaneously. As experiments proceeded, it was evident that machine processing of data was necessary. The programming effort to accomplish this evolved into a computer program which has completely automated all data processing and analysis; the output is also graphed by machine plotting.

One complete set of experiments has been completed for a rhodamine-B dye and a Dowex 50 resin; this includes experimental results and analyses at four temperatures, $10^{o}C$, $20^{o}C$, $30^{o}C$, and $40^{o}C$. These results imply a kinetic rate law which is second order with respect to sorbate and sorbent, but which has a rate coefficient which is dependent upon degree of sorbent saturation with sorbate and sorbate concentration. This latter relationship is well defined functionally for all four temperatures. In addition, temperature is seen to affect the rate coefficient in a consistent functional manner.

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EC-00194-02 (Continued)

The activities for year 02 will verify the kinetic rate law for other sorbate-sorbent systems in orue to further test its generality. The non-flow kinetics will then be applied to a computer model of a flow system in order to predict breakthrough profiles; these profiles will be compared with measured profiles from an experimental flow system.

The results of the research will have application in the design of fixed bed flow reactors for removal of water contaminants and in assessing the travel of chemical pollution in groundwater.

Publications: None

EC-00195-02
(UI-00356-02)

NITRATE DETERMINATION USING CHROMIUM (II) COMPLEXES

JOHN G. MASON
VIRGINIA POLYTECHNIC INSTITUTE
BLACKSBURG, VIRGINIA

Objectives: The determination of nitrate by usual methods is subject to interferences by nitrite and hydroxylamine and is not readily adapted to automatic operation. The objectives of the proposed research are:

1. To develop a rapid, accurate, and selective electrochemical method for the determination of nitrate in water in the presence of nitrite and hydroxylamine using electrogenerated Cr(II) complexes as reducing agents.

2. To explore the extent to which such a technique could be automated.

3. To elucidate aspects of the mechanism of the reduction of nitrate to hydroxylamine to ammonia by Cr(II) complexes.

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EC-00195-02 (Continued)

Significant Results: During Fiscal Year 1969, the following things were accomplished:

1. The electrochemistry of a series of Cr(III) complexes in the presence of, and in the absence of NO_3 was investigated. It was found that the ability to reduce nitrate via electrolytically generated Cr(II) critically depended upon the structure of the complex.

2. The electrochemistry of the reduction of the series of Cr(III) complexes derived from ethylenediaminetetraacetic acid was investigated in detail. It was found that in ammonia-ammonium ion buffers, the electroreduction of the complex was profoundly influenced by the presence of both nitrate and nitrite. An analytical technique was developed which is sensitive in the 10^{-4}-10^{-3} M range. It is evident, however, that the species responsible for the results is not the Cr(II) complex but rather a mixed complex formed upon reduction of Cr(III)-EDTA.

3. Previous reports of the analytical utility of Cr(III)-glycine complexes were and are being re-examined. To date, the results indicate that only one Cr(III)-glycine complex is effective.

Publications: None

EC-00196-02 (UI-00366-02) ISOLATION OF VIRUS FROM SEWAGE AND DRINKING WATER

WALTER N. MACK
MICHIGAN STATE UNIVERSITY
EAST LANSING, MICHIGAN

Objectives:

1. To make a quantitative study of the viruses present in the various stages of activated sludge sewage treatment.

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EC-00196-02 (Continued)

2. To test the effectiveness of chlorine, holding time, temperature, etc. on the viruses present in the effluent.

3. To determine what happens to the viruses in effluents after being discharged into a river.

4. To attempt to isolate enteroviruses from potable water taken from chlorinated municipal water supply and also private wells known to produce a high incidence of hepatitis in individuals using the water.

Significant Results: During June through October 1969, 592 sewage and river water samples were collected to be tested for the enteroviruses. Sewage samples consisted of 467 samples collected at the various steps through a new activated sludge treatment plant. There were 125 samples of water collected from the Red Cedar River at/or 449 feet below the effluent discharge. Samples were tested for virus by inoculating monkey kidney cultures with ultracentrifuged concentrated samples of sewage or water.

Preliminary results show that viruses are present in the influent and raw sludge and that the unchlorinated effluent also contains viruses. Chlorination of the effluent (averaging from 4.2 to 6 ppm chlorine, with a one-hour holding time) reduced the amount of virus but virus was recovered in river waters downstream from the outflow. Eight of 29 samples (27 percent) of the river water collected from 10 to 50 feet downstream from the outflow contained virus.

The next problem is to determine what happens to the virus in the river. It must be emphasized that these results are from a new waste water treatment plant using adequate chlorine and holding time.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00280-02 (UI-00600-02)	NUTRITIONAL VALUE & UTILIZATION OF ALGAE	FRIEDA B. TAUB UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

Objectives: The nutritional availability of algae for zooplankton is still poorly understood. Work in this and other laboratories indicates that an inadequate level of required growth factors in the algae may limit zooplankton grazing and thus contribute to the persistence of algal blooms. Products of other microorganisms or other source of growth factors are apparently necessary for efficient utilization and successful reproduction by Daphnia and Tetrahymena when the alga Chlamydomonas provides the sole source of nutrients.

The protozoan, Tetrahymena, which has both the ability to grow axenically in defined organic media and the ability to ingest small algae cells, will be used to determine the nutritional value of the algae. By determining the required factors which can be replaced by the algae, the algal contribution, and by difference, the deficiencies can be ascertained. An algal toxin may be indicated if the growth of Tetrahymena in a complete medium is poorer when algal cells are present. In this event tests will be undertaken to determine if this is due to a competitive metabolic inhibitor.

Other algae, protozoans and cladocerans will be tested to determine the degree to which nutritional patterns shown in the above studies may hold for other organisms.

Combined laboratory and field studies will attempt to determine the role of such factors in the utilization of algae in lakes and sewage treatment plants. Natural waters will be bioassayed and the defined factors will be added to determine their effect.

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EC-00280-02 (Continued)

Significant Results: To date the results have indicated:

1. An amino acid deficiency or imbalance is responsible for reduced protozoan growth when feeding occurs in the dark; vitamins, nucleic acids, and glucose supplements are not beneficial in the absence of added amino acids.

2. A vitamin deficiency occurs in addition when the feeding occurs in the light, indicating that a light labile vitamin, e.g., folic acid, may be involved.

3. The growth of the protozoan yields a dose response to various levels of amino acid supplementation; this beneficial effect cannot be achieved when the equivalent weight of glucose is substituted for the amino acids.

4. Partial mixtures of amino acids sometimes given greater stimulation than complete mixtures. Suprisingly, methionine and tryptophan do not seem to be necessary for stimulatory effects. Arginine supplementation may be inhibitory.

5. In the dark, a marked reduction in algal concentration has been demonstrated due to the protozoan feeding since the algae cannot grow in the dark.

6. In the light, no significant reduction in algal concentration occurs; presumably the algae are regrowing at the same rate as they are eaten.

All of these results must be considered preliminary and subject to confirmation. Work will continue only for a few months in an attempt to identify the particular compounds required for the increased efficiency in algal utilization.

Identification of these nutritional inadequacies and imbalances suggest the possibility that increased algal growth caused by eutrophication might indeed be channeled through desirable food chains at a more rapid rate and thus avoid some of the problems associated

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EC-00280-02 (Continued)

with algal blooms. Within sewage treatment ponds, more active cropping by the zooplankton could result in more rapid oxidation and purification. The nutritional value of algae must also be known for use in aquaculture, where it serves as food for shellfish and crustaceans, as an animal feed additive, or even potentially as human food.

Publications: None

EC-00284-02
(UI-00638-02)

PHYTOPLANKTON, SUSPENDED MATERIALS AND TURBIDITY

ROBERT W. HOLMES
UNIVERSITY OF CALIFORNIA
SANTA BARBARA, CALIFORNIA

Objectives: The objective of the research is to establish and evaluate the relationships between water turbidity and organic and inorganic particle concentration (i.e. seston) in a turbid inshore marine environment.

Visual observations have shown the existence of turbid water in the zone between the kelp and shore along the sparsely inhabited coastal region between Santa Barbara and Point Conception. Very high mussel growth rates have been observed in this zone, suggesting the existence and production of sizeable quantities of suspended organic materials which almost certainly contribute appreciably to water turbidity. The suspended organic material is probably locally produced by planktonic algae and/or by the fragmentation of kelp. The sources, relative contribution, and relationships between the inorganic and organic fractions of the seston and its correlation with water turbidity will be evaluated seasonally and geographically.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00291-02 (UI-00697-02)	STRUCTURE OF THE BLUE-GREEN ALGA TOXIN	BORIS WEINSTEIN UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

Objectives: For the past three years the P.I. has been working on the synthesis of a polypeptide hormone (glucagon), as well as methods for the gas chromatographic and mass spectral analysis of polypeptides. The specific aims are:

1. To apply these techniques to the determination of the structure, and the possible synthesis of the blue-green alga toxin.

2. To undertake the synthesis of the cyclic polypeptides malformin, phalloidin, echinomycin, and sporidesmin, each of which is a toxic product.

3. In the structural area, to study cobra and rattlesnake venoms.

It is felt that a coordinated research effort in the area of polypeptide structure and synthesis can yield many scientific dividends, in both the organic and biochemical fields.

Significant Results: During this past grant period, a new technique was developed for obtaining the toxin, which is called microcystin. Material having a toxicity of $LD_{100} = 0.1$ mg/Kg; in mice, has now been obtained. This product appears to have a molecular weight of about 1800, no free N-terminus, and an amino acid content of alanine, arginine, aspartic acid, glutamic acid, glycine, isoleucine, ornithine, proline, serine, threonine, tyrosine and valine. Mass spectral fragmentation studies will soon be started on the toxin.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00294-02 (UI-00708-02)	CHEMISTRY OF ALGAL TOXINS	MIYOSHI IKAWA UNIVERSITY OF NEW HAMPSHIRE DURHAM, NEW HAMPSHIRE

Objectives: This project is being undertaken to (a) study the occurrence of toxin-producing algae in local lake, estuarine and marine waters and (b) isolate and characterize toxic substances produced by algae. Toxicity is being determined through assays involving Bacillus megaterium spores, Chlorella pyrenoidosa, and mice. Initial studies are involved with the isolation of toxic substances produced by the blue-green alga Aphanazomenon flos-aquae, which blooms profusely in certain of the lakes in New Hampshire and which is implicated in recent incidents of fish kills, and by the dinoflagellate Gymnodinium breve, which occurs in blooms in the Gulf of Mexico.

Significant Results: A paper was prepared which demonstrates the value of the micro-organism Chlorella for the detection of certain toxic substances present in marine red algae. This offers an approach to the discovery of substances which will inhibit the growth of green algae, which can become a nuisance in fresh water lakes and ponds during the warm seasons.

Considerable progress has been made in the isolation of the toxins present in the dinoflagellate Gymnodinium breve, an organism which causes red tides off the coast of Florida in the Gulf of Mexico and which has been implicated in fish kills and in cases of paralytic shellfish poisoning. Several fractions toxic to mice have been isolated. These fractions have also been found (by Professor J. Sasner of the Department of Zoology) to possess neurotoxic activity.

Considerable progress has also been made during 1969 in the isolation of the toxin from the blue-green alga Aphanazomenon flos-aquae. This new alga blooms profusely during the summer months in some of the fresh water lakes of New Hampshire. It not only pollutes the water esthetically but has also been implicated in massive fish kills. Purification procedures have been worked out which have yielded small quantities of

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EC-00294-02 (Continued)

what appear to be pure toxic substance. Larger batches of algae are presently being worked up to yield enough toxin for further characterization.

Publications: None

EC-00295-06 (UI-00717-06)

PLUTONIUM REMOVAL IN WATER TREATMENT

JULIAN B. ANDELMAN
UNIVERSITY OF PITTSBURGH
PITTSBURGH, PENNSYLVANIA

Objectives: The aim of this investigation is to study the effect of the various processes in current municipal water treatment practice on the removal of plutonium from a raw water supply, so as to be able to adjust these procedures for optimum removal. The major portion of the study will be concerned with studying the various treatment operations separately as to their effect on the state of plutonium and its ability to be removed in a given process or a subsequent or simultaneous one. When these are sufficiently understood, the operations will be combined into a bench scale pilot plant in order to interrelate them and attain the most efficient removal of plutonium. The oxidation state of the plutonium, the size and charge of colloidal and larger aggregates, the influence of added or natural occurring complexing agents, and coprecipitation phenomena will be of principal consideration. The operations to be studied will be chlorination, lime-soda softening, coagulation and flocculation, and sand and carbon filtration. It is expected that a thorough understanding of the role of each of these processes as related to the chemistry of plutonium will result in recommendations for reasonably and conveniently adjusting conventional water treatment processes so as to produce a water safe to drink, even in the event of gross contamination by plutonium in the raw water supply.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: No additional publications.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00296-02 (UI-00719-02)	TRANSPORT MECHANISMS IN WATER FILTRATION	CHARLES R. O'MELIA UNIVERSITY OF NORTH CAROLINA CHAPEL HILL, NORTH CAROLINA

Objectives: The principal objective of the proposed research is to identify and quantitatively define the mechanisms by which suspended particles are transported to the liquid-filter interface in water filtration. More specifically, the research will attempt to develop a transport model for the filtration process and to test this model experimentally.

Development of the transport model will include the following steps:

1. Describe the force system acting on a single particle.

2. Based on such a force system, develop a differential equation describing the rate of change of particle concentration in a differential volume of fluid.

3. Consider the flow pattern of these fluid elements past a single collector.

4. From steps 2 and 3, describe the total flux of particles to a spherical collector, and determine the removal efficiency of a single collector.

It is anticipated that experimental testing of the transport model will concentrate on an evaluation of the influence of suspended particle size on the filtration process. Particular emphasis will be placed on defining the critical particle size range within a minimum transport efficiency exists.

Significant Results: There is no significant difference in FY 69 from that in FY 68.

Publications: Yao, Kuan-Mu and O'Melia, Charles R. "Particle Transport in Aqueous Flow Through Porous Media." ESE Publ. No. 210. Presented at the 16th Annual Conference of the Hydraulics Divn. of ASCE. August 20-22, 1968. MIT, Cambridge, Massachusetts.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00298-02 (UI-00723-02)	ULTRAFILTERS IN BIOLOGICAL RECOVERY PROCESSES	DANIEL I. C. WANG MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS

Objectives: The objectives are: (1) to evaluate in detail but in a systematic manner, flow rate behavior of commercially available ultrafiltration membranes due to various physical and chemical environments. Following this initial evaluation, those membranes possessing the highest potentials shall be selected and employed; (2) to isolate, to concentrate and to purify bacteriophages and viruses in model systems, food systems and sewage systems; (3) to test the ultrafiltration membranes in their ability to concentrate and purify micro- and macro-molecules such as enzymes and proteins. If these objectives are met, membrane ultrafiltration coupled with ion exchange and/or ultracentrifugation may open many doors in the general area of isolation, concentration and purification of biologically active substances.

Significant Results: The application of ultrafiltration membranes in biological recovery processes has proceeded in several directions. The preliminary studies have been involved in the examination of commercially available ultrafiltration membranes with respect to their ultrafiltration fluxes in various chemical environments at different physical conditions. The environmental conditions which were examined were the influences of inorganic and organic salt solutions on the rate of ultrafiltration. The membranes tested included polyelectrolyte and cellulose acetate polymers. It was found that the common ionic compounds, both organic and inorganic in nature, commonly associated with biological solutions play a profound role in reduction of membrane fluxes. A general behavior with both types of membranes showed a greater flux reduction associated with the increasing charge of the anionic moiety of the salts. The effects of the physical environment on membrane fluxes included temperature and pressure. A typical Arrhenius temperature relationship was found for the membrane

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EC-00298-02 (Continued)

ultrafiltration rate. Activation energies on the order of 4000 cal/mole were generally encountered. Increasing filtration pressure generally resulted in a linear increase on the ultrafiltration rate. However, the different types of membranes exhibited different upper limits of filtration pressure for this linearity.

Macromolecular materials have also been examined using ultrafiltration membranes for their recovery. A typical study was the concentration and purification of a crude enzyme (trypsin) preparation. This enzyme, possessing a molecular weight of approximately 25,000, was shown to have contaminating protein materials in the molecular weight range of 12,000 to 19,000. A cellulose acetate membrane capable of retaining macromolecules above a nominal molecular weight of 20,000 was selected for the concentration and purification of this preparation. The results from a single-pass filtration experiment yielded an 8.35 fold concentration accompanied by a 2.35 purification factor. Findings of this type indicate the tremendous potential and simplicity of ultrafiltration membranes with biological solutions.

Lastly, the use of ultrafiltration membranes has been examined in the recovery of viruses from suspension. An attenuated strain of polio virus cultivated in mammalian tissue culture was used. A polyelectrolyte membrane capable of passing materials up to molecular weights of 100,000 was examined for the virus concentration and purification. Twenty-fold concentration factor was routinely attained with a quantitative recovery of the virus. Accompanied with this concentration, purification factors as high as 15-fold has been obtained.

Publications: None

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EC-00299-02 (UI-00730-02)	MICROBIOLOGY OF ESTUARINE AND SHELLFISH POLLUTION	LAWRENCE W. SLANETZ UNIVERSITY OF NEW HAMPSHIRE DURHAM, NEW HAMPSHIRE

Objectives: This research is designed to (1) determine the reliability of current bacteriological criteria or standards for monitoring the sanitary quality of shellfish and shellfish growing waters, (2) determine whether fecal streptococci should replace coliforms as indicators of fecal contamination of estuarine water and shellfish, (3) determine whether bacteriophages will be useful indicators of enteric virus contamination of estuarine water and shellfish, (4) evaluate depuration procedures and factors which affect the decontamination of oysters and clams under laboratory and field conditions, (5) determine the efficiency of newly installed sewage treatment plants in reducing or eliminating contamination of estuarine waters with enteric bacteria and viruses.

Significant Results: Studies continue to demonstrate that salmonellae and enteric viruses were present in estuarine water and in oysters harvested from estuarine waters which had coliform media counts of not over 70/100ml, the standard used by the U.S. Public Health Service for approved areas for the harvesting of oysters. A method was developed for the enumeration on quantitation of salmonellae in estuarine water and oyster samples. Particular attention was given to determining whether bacteriophages are more specific indicators of the presence of enteric viruses in estuarine water and oysters than are the coliforms or fecal streptococci. Findings to date indicate the possibility of a good correlation between the occurrence of coliphages and enteric viruses in shellfish growing waters and in shellfish harvested from waters which are exposed to varying degrees of pollution from domestic wastes.

Publications: None

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EC-00300-01 (UI-00736-01)	WATER-BORNE VIRUSES, RECOVERY BY ELECTROPHORETIC-FILTRATION	BENJAMIN H. SWEET GULF SOUTH RESEARCH INSTITUTE BATON ROUGE, LOUISIANA

Objectives: The specific objectives are: (1) to evaluate the efficacy of the Bier-Polusen electrophoretic-filtration apparatus as a tool to concentrate animal viruses from water under experimental conditions; (2) to determine if this method in conjunction with sensitive viral assay can be quantitative enough to detect small amounts of entroviruses under experimental conditions; (3) to determine the existence of qualitative differences in this method using different viruses and mixtures of viruses; and (4) to apply this procedure to the detection and quantitation of viruses in polluted waters.

Significant Results: Established a virus model system using the Chat strain of Type 1 polio which was assayed by a plaque method on Vero cells. Six plaque forming units/0.2, with a SD of ± 1 could be detected. In addition the stability of polio virus under different conditions was studied. These conditions included salt concentration, temperature, and voltage variations. It was determined that Borate buffer (0.27%, pH 8.6) with Tween-80 (20 g/ml) was the most efficient buffer to be used for electrophoretic filtration.

Familiarization with the Canalco Electrophoretic-Filtrator-Concentrator. Six functions are possible with this unit: desalting, concentration, filtration, fractionation, washing, and sterilization. In a single study using electro-osmosis, we were able to concentrate the virus 5.5 fold, and the water volume 7-fold in 2.5 hours. Two studies were carried out by fractionation. In the first, the Canalco apparatus was used so that virus moved counter to the liquid flow. Using about 700 plaque forming units/ml and a Whattman #54 filter, we were able to concentrate virus 2.6-fold in 1 hour with $129 V/cm^2$ with 100 percent recovery rate. In the second study, the conditions were

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EC-00300-01 (Continued)

the same, except that a set up was used so that the virus moved with the liquid flow. A concentration of 2.6-fold was achieved with 90 percent recovery of virus. Enhancement of concentration is deemed possible with variations of proper pump placement and variation in pump rates.

Publications: None

EC-00318-01 (UI-00874-01)

WATER QUALITY MONITORING IN DISTRIBUTION SYSTEMS

ROBERT M. BROWN
NATIONAL SANITATION FOUNDATION
ANN ARBOR, MICHIGAN

Objectives: This project undertakes the development and refinement of sensors and automated techniques for water quality monitoring in distribution systems. The proposal lists fourteen parameters to be measured including flow rate and pressure temperature, specific conductance, pH, turbidity, dissolved oxygen, chlorides and sulphates, fluorides, residual chlorine, alkalinity, hardness, calcium carbonate stability, trace metal ions, and other organic matter. Sensors for measuring many of these are currently available and are sold commercially as "monitors." There are now no methods available for monitoring such parameters as organic matter and calcium carbonate stability, and therefore, in these cases attention will be given to developing methods whereby such parameters can be incorporated into the monitor system. Other parameters presently monitored require sensors with a greater degree of sensitivity than those presently available in order to determine trace amounts of contaminants in water distribution systems.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00321-01 (UI-00882-01)	REMOVAL OF VIRUSES IN WATER BY DIATOMITE FILTRATION	R. S. ENGELBRECHT UNIVERSITY OF ILLINOIS URBANA, ILLINOIS

Objectives: 1. To study the effectiveness of diatomite filter aids (fluxcalcined and coagulant coated) in removing viruses in filtration.

2. To evaluate the potential of polyelectrolyte coated diatomite filter aids in removing viruses.

3. To investigate the role of activated carbon in improving the virus removal efficiency of diatomite filtration.

The experiments will be conducted with a laboratory scale filtration unit which will allow accurate control of a number of variables to be studied. The unit will be operated under conditions which simulate those found in full-scale filtration systems now in use. The major variables to be tested are the type of diatomite filter aids, amount of polyelectrolyte coating, pH, depth of filter cake, flow rate and amount of activated carbon.

The virus to be used in the first part of the study is the T4 coliphage. Results obtained with this bacteriophage will then be compared with results obtained with a swine entero-virus. Assistance with production and assay of the animal virus will be obtained from the Department of Veterinary Medicine where facilities are available for this type of work.

Significant Results: In initiating the study in March 1969, major attention was given to the development of necessary laboratory apparatus. A bench-scale diatomite filtration plant was constructed. The filter chamber has a filter cake surface area of 0.00852 feet^2. Flow rates of 0.5 to 3.0 gpm/ft^2 can be used. The significant advantage of this apparatus is the relatively small volume of water required to perform a given experiment. It was necessary to give special attention to the size of the experimental

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION

EC-00321-01 (Continued)

apparatus because of the problems associated with the culturing and harvesting of virus; at the same time, the size of the apparatus had to be adequate to give reliable results, interpretable in terms of field practice.

Experiments performed during fiscal year 1969 used an 0.5 inch deep, preformed filter cake. At a flow rate of 1.0 gpm/ft^2, the results indicated that commercially available diatomite filter aids were inefficient in removing viruses from water. Not more than 10 to 15 percent of the model virus, Escherichia coli bacteriophage T4, could be removed by filtration using these filter aids. In order to improve the efficiency of virus removal, diatomite filter aids coated with a water soluble cationic polyelectrolyte (Purifloc C31 - Dow Chemical Co.) have been employed. Under similar experimental conditions, coated diatomite filter aids have been found to remove more than 99 percent of the virus particles from water. Presently these experiments are continuing and are being extended to study the effects of higher filtration rates, pH and turbidity on virus removal.

Publications: None

EC-00323-01 (UI-00904-01)

IMPROVED DRINKING WATER QUALITY THROUGH DUAL SYSTEMS

DANIEL A. OKUN
UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, NORTH CAROLINA

Objectives: The purpose of this research study is to investigate the economic feasibility of providing two separate water supply systems for urban areas--one for potable purposes (drinking and cooking)--the second one for all other purposes. The emphasis is to investigate these separate systems for new developments--not to change over old, existing systems. Specifically, the following points will be investigated in detail:

1. The capacity requirements of dual systems

GRANT NO.	TITLE OF PROJECT, OBJECTIVES, SIGNIFICANT RESULTS & PUBLICATIONS	PRINCIPAL INVESTIGATOR & LOCATION
EC-00323-01 (Continued)		

2. A catalog of existing sources of water supply and their quality

3. Development of cost data for water treatment as a function of the raw water quality

4. To study the economics of the small quantity transmission and distribution systems

5. To review the jurisdictional and institutional problems.

Significant Results: This is a new project, therefore significant progress is not available.

Publications: None

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00015-09 (UI-01027-09)	CHEMISTRY & BIOLOGY OF AIR & WATER RESOURCES	A. JOEL KAPLOVSKY RUTGERS, THE STATE UNIVERSITY NEW BRUNSWICK, NEW JERSEY

Objectives: To train qualified students working for MS and Ph.D. degrees and to supply those trained personnel to the field. Two programs leading to the MS degree are available, one with and one without thesis. The latter is based primarily on prescribed series of courses and an expository essay.

EC-00026-07 (UI-01057-07)	ENVIRONMENTAL BIOLOGY	LOREN D. JENSEN JOHNS HOPKINS UNIVERSITY BALTIMORE, MARYLAND

Objectives: To continue the existing interdepartmental research training program of environmental biology in the public health aspects of hazardous and potentially hazardous environmental contamination. A particular area of specialization in this program is the quality of aspects of domestic, recreational and industrial water supplies. Students are being trained in the detection, measurement and biological evaluation of radiological, chemical and biological contaminants of significance to the public health.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00029-02 (UI-01063-02)	WATER QUALITY TRAINING FOR APPLIED SCIENTISTS	RUSSELL F. CHRISTMAN UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

Objectives: To admit biologists and chemists with BS or MS degrees in their respective fields into the graduate program in Applied Science within the Water and Air Resources Division of the Department of Civil Engineering. This program offers scientists an MS or Ph.D. curriculum comprised of course work in Water Chemistry and Biology concurrent with graduate sequences of courses in closely allied disciplines.

To focus scientists' research efforts on the complex research problem areas of water quality as it affects man's health and welfare.

EC-00034-09 (UI-01028-09)	SANITARY ENGINEERING	ERMAN A. PEARSON UNIVERSITY OF CALIFORNIA BERKELEY, CALIFORNIA

Objectives: To provide support for research training programs designed to provide the sanitary engineering, public health engineering, environmental engineering and teaching and research professions associated therewith, highly qualified engineer-scientists capable of conceiving, conducting and directing creative engineering design and research programs essential for protection of the environment in modern urban industrial society. The grant stimulates graduate engineers to participate in research activity which requires the fullest use of the scientific and engineering principles with which their educational program is concerned and which is directed to the needs of man.

GRANT NO.	TITLE OF PROJECT, OBJECTIVES & PUBLICATIONS	PROGRAM DIRECTOR & LOCATION
EC-00088-05 (UI-01041-05)	OCEANOGRAPHY	DAVID M. PRATT UNIVERSITY OF RHODE ISLAND KINGSTON, RHODE ISLAND

Objectives: To train graduate students working for the Ph.D. in Oceanography, a subject of growing importance to problems of public health. These students need not have had previous training in oceanography. Approximately the first two years of the program are spent in a generalized curriculum in the basic subdivisions of the field, before the student has elected a particular area and can qualify for financial support from research contracts or special projects. The Traineeships are therefore invaluable in attracting promising candidates and providing support for their initial years in the program.

BWH TRAINING GRANT TRANSFERRED TO THE FOOD AND DRUG ADMINISTRATION

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FD-00011-05 (UI-01039-05)	SHELLFISH SANITATION	ALBERT K. SPARKS UNIVERSITY OF WASHINGTON SEATTLE, WASHINGTON

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